SITUATIONAL ANALYSIS OF FRENCH DAIRY HEIFERS INTAKE

DANIÈLE TREMBLAIS

ABSTRACT

The French project INGELA, dairy heifers intake (or Ingestion des Genisses Laitière in French), aims to update the data on the dairy heifer intake capacity. It is based on two main actions: an overview of the current situation and an experimental trial at the INRAE farm in the Pin au Haras in Normandy. In this study are presented the results of the first part of the project.

In order to report the current situation of dairy heifer intake, two separate actions were carried out. In the fall of 2020, a field survey of dairy advisors was conducted, and 21 responses were obtained, providing an overview of the forages and winter diets used on farms. Also, the points of view of the advisors about dairy heifers intake were collected. At the same time, an analysis of group of dairy heifer's intake data from French experimental farms was also done. These intake measurements were collected from 5 experimental farms and 66 group data were analyzed for dairy heifers weighing an average of 400 kg and 15 months old.

Forages given to dairy heifers are mostly grass-based (hay, grass silage, bailed silage), and are poorly analyzed on the farm. Added to this, is the fact that the assessment of the weight of heifers is approximate, and because the objective of the farmers differs, the advice on feeding and diets calculation given by professionals can be distorted. Hence a great variability in the responses given, from simple to double, between the minimum and the maximum in quantity of DMI. There is on average a difference of 20% on DMI with hay diet between the 1st quartile and the 3rd quartile for all heifer categories, 6, 12, and 18 months. This difference is on average 25% for a grass-silage diet.

For the analysis of experimental farm data, after removing inconsistent data, measured heifer groups intake during the trials differ little from the intake predicted by INRA 2018 feeding system. Out of 58 data of preserved intake, more than 75% of these intakes have a difference between ±15% with the intake predicted by INRation v.4. More than half of these 75% have a difference of less than ±5%. This is due to a relatively more important accuracy of heifer weights and forage values than the data collected from the survey.

But French dairy heifers DMI are lower than dairy heifers DMI from other countries, a deeper analysis is needed to understand the real reason of this differences.

When the parameters considered in the calculation of intake of dairy heifers are precise, such as the weight of the dairy heifer as well as the forage values (energy, fill value), the French

INRAE feeding system correctly predicts ingestion. These conclusions will be refined by individual ingestion measures in the second part of the INGELA project.

ABSTRACT (FRENCH)

Le projet français INGELA, Ingestion des Génisses Laitières, a pour but de mettre à jour les données en matière de capacité d'ingestion chez la génisse laitière. Il s'articule autour de deux principales actions : un état des lieux de la situation actuelle ainsi qu'un essai expérimental à la ferme INRAE du Pin au Haras en Normandie. Cette étude traite de la première partie du projet.

Afin de rendre compte de la situation actuelle en matière d'ingestion chez la génisse laitière, deux actions distinctes ont été réalisées. La première est une enquête au cours de l'automne 2020, auprès de conseillers spécialisés en élevage laitier dans le but d'obtenir un aperçu des rations utilisées en ferme pour alimenter les génisses laitières ainsi que et leurs points de vue en matière d'ingestion. La seconde est une analyse de données d'ingestion de groupes de génisses issues de 5 fermes expérimentales françaises.

Au total, la première étape a permis de recueillir 21 réponses complètes de conseil des principales régions laitières Françaises. La seconde a permis de constituer un jeu de données des performances de mesures de 66 groupes de génisses laitières pesant en moyenne 400 Kg et âgées de 15 mois.

Les fourrages donnés aux génisses laitières sont majoritairement à base d'herbe (foin, ensilage d'herbe, enrubannage), et sont peu analysés en exploitation. Les résultats des enquêtes montrent que l'appréciation du poids des génisses est approximative, les objectifs des éleveurs diffèrent ce qui a pour conséquence des conseils en matière d'alimentation et de rationnement parfois approximatif. Ceci explique la grande variabilité dans les réponses données au sujet de l'ingestion des génisses avec des valeurs qui varient du simple au double. Il y a une différence de 20 % en moyenne en quantité de matières sèches ingéres de foin proposées par les conseillers entre le 1er quartile et le 3eme quartile pour toutes les catégories de génisses, soit 6, 12, et 18 mois. Cette différence est en moyenne de 25% pour une ration à base d'ensilage d'herbe.

L'analyse des données des fermes expérimentales montre quelles ingestions mesurées des groupes de génisses pendant les essais diffèrent peu des ingestions prédites par le système d'alimentation INRA 2018. Sur 58 données d'ingestions conservées, plus de 75% de ces

ingestions ont une différence comprise entre ±15% avec les ingestions prédites par INRation v.4. Plus de la moitié de ces 75% ont une différence inférieure à +/-5%. Cela s'expliquant par une précision relativement plus importante des poids des génisses et des valeurs des fourrages, comparées aux données issues des enquêtes terrain.

Lorsque que les paramètres pris en compte dans le calcul d'ingestion des génisses laitières sont précis, notamment le poids de la génisse laitière ainsi et les valeurs du fourrage (énergie, encombrement), le système d'alimentation français d'INRAE semble prédire correctement l'ingestion.

Ces conclusions seront affinées par des mesures individuelles d'ingestion dans le cadre de la seconde partie du projet INGELA.

THESIS

SITUATIONAL ANALYSIS OF FRENCH DAIRY HEIFERS INTAKE

Factors of variation, dairy advisor's opinion, recommendations, and farm data

Submitted by

Danièle Tremblais

For the degree of

European Engineer Degree in Livestock Production

AERES University of Applied Sciences, Dronten

2020-2021

Written in France

Thesis supervisor

Geronda Klop

Lecturer in animal nutrition

Sponsor of the report

Institut de l'Elevage / French Breeding Company

PREFACE AND ACKNOWLEDGEMENT

This thesis was written as part of the European Engineer Degree in Livestock Production at AERES, University of Applied Sciences.

The objective of the INGELA project is to update dairy heifer capacity intake data. This project will be useful to improve feeding of the dairy heifers for farmers and dairy advisors when attempting to optimize the performance and to reduce feeding costs of the herd. This thesis also aimed to be the initial part of a larger project to update dry matter intake benchmarks for French dairy heifers.

I am thankful for the advices and skilled guidance of my supervisor from

the French Livestock Institute, the rearing youngstock and dairy cows nutrition Project Manager Julien Jurquet

from the French National Research Institute for Agriculture, Food and Environment, the Professor Yannick Le Cozler.

Thank you for allowing me to expand my thinking through our discussions.

I am also grateful to the Animal nutrition lecturer Geronda Klop for taking the time to talk with me throughout the project and guiding me in my choices.

Many people assisted with this thesis by providing data and I also want to express my gratitude:

Lucie Morin, Director of Experimental farm of Normandy – Blanche Maison

David Plouzin, technician the experimental farm Trinottières

Laurent Brunet, study engineer at Mirecourt experimental farm

Guylaine Trou, research officer at the experimental farm Trevarez

FINALLY, I WANT TO THANK MY FAMILY FOR SUPPORTING ME ALL THE WAY THROUGH THIS PROCESS, AS WELL AS MY FRIEND TAHNEE FOR PROOFREADING MY SCRIPTS.

TABLE OF CONTENTS

Page

I. Introduction ..... - 1 -
Definition ..... - 3 -
Factors affecting DMI: Animal factors ..... - 3 -
Physical regulation of feed intake ..... - 3 -
Physiological regulation of feed intake ..... - 3 -
Genetic ..... - 4 -
Factors affecting DMI: Feed factors ..... - 4 -
Direct factors ..... - 4 -
Indirect factors ..... - 6 -
Factors affecting DMI: Environmental factors ..... - 6 -
Rearing strategy ..... - 6 -
Feeding methods ..... - 7 -
Climate / atmosphere ..... - 8 -
Actual data and models of intake prediction ..... - 8 -
Example of rations during winter period ..... - 8 -
Intake calculation prediction ..... - 10 -
Knowledge gap and research question ..... - 14 -
II. Materials and methods 17
How do French dairy advisors opinions and recommendations about dairy heifers intake on a winter diet based position themselves in relation to the French feeding system? 17
Do recent intake measurements in heifers on a winter diet correspond to literature data currently used in French feed formulation software? 18
What are differences in DMI estimates for dairy heifers on a winter diet between France and other countries? 21
III. REsults ..... **Erreur ! Signet non défini.**
Survey aimed at dairy heifer advisors: How do French dairy advisors opinions and recommendations about dairy heifers intake on a winter diet based position themselves in relation to the French feeding system? 24
Do recent intake measurements in heifers on a winter diet correspond to literature data currently used in French feed formulation software? 30
general presentation 30
What are differences in DMI estimates for dairy heifers on a winter diet between France and other countries? 41

IV. Discussion 44

How do French dairy advisors opinions and recommendations about dairy heifers intake on a winter diet based position themselves in relation to the French feeding system? 44

Do recent intake measurements in heifers on a winter diet correspond to literature data currently used in French feed formulation software? 45

What are differences in DMI estimates for dairy heifers on a winter diet between France and other countries? 48

V. Conclusion 49

VI. BIBLIOGRAPHY 50

Appendix 1 53

Appendix 2 55

TABLE OF FIGURES AND TABLES

Table

Figure 1: NDF digestibility of forage species (Hoffman, 2001) ..... - 6 -

Figure 2: Adapted from different sources, « De l'herbe récoltée pour alimenter les génisses laitières, Chambre d'agriculture Nord-Pas de Calais (2010), Itinéraire technique génisses Prim'Holstain, Chambre de l'agriculture Meurthe et Moselle (2014), Alimentation minérale des génisses laitières : Optimiser l'apport de minéraux, Chambre d'agriculture Bretagne (2008), Génisses laitières, moins de tracas, plus de résultats, Chambres d'Agriculture de Bretagne (2017), Utiliser des aliments fermiers pour élever les génisses, Institut de l'Elevage (2017), Alimentation des génisses laitières : Foin, enrubannage, ensilage ou paille : quelle ration choisir ? Vergonjeanne (2015), Les jeunes femelles d'élevage : un capital à faire fructifier, Institut de l'Elevage (2014) ..... - 10 -

Figure 3: Gross DMI from roughages (GDM) and net roughages intake in kgDM per animal per day with matching concentrates supply (app. 90% DM and 940VEM) in kg/animal/day, for indoor-fed young stock, depending on BW, desired growth rate, and VEM content in the roughages (CVB, 2016)..... - 12 -

Figure 4: Map of France listing all the respondents..... 24

Figure 5: Forage predominance for dairy heifers aged between 6 and 12 months 25

Figure 6: Forage predominance for dairy heifers aged between 12 and 18 months 26

Figure 7: Advisor's estimations of heifers DMI for 3 different ages 27

Figure 8: Composition of dairy heifer diets aged of 6 months, 12 months, and 18 months proposed by respondents 28

Figure 9: Mean of total DMI per group of heifers depending on the BW average of the heifer group..... 33

Figure 10: Distribution of DMI per heifer per day per class of BW..... 34

Figure 11: Average quantity of the main ingredients in the diet, depending on the main forage 36

Figure 12: Mean of the heifer group DMI with hay as main forage of the diet..... 37

Figure 14: Comparison between real DMI and predicted DMI by INRation v.4, categorized by the main forage..... 39

Table 1: Prediction example of intake for Holstein dairy heifers, depending on their age and the AFC objective (Chambre d'agriculture Meurthe et Moselle, 2014)..... - 7 -

Table 2: Number of dairy heifers diet found from non-scientific references: farmers' association, breeding advisoring company..... - 8 -

Table 3: Equation of DMI prediction from 4 different feeding systems. Based on INRA (2018), NRC (2001), NorFor (2011), CVB (2016) ..... - 10 -

Table 4: List of variables of DMI equation of prediction from INRA (2018), NRC (2001), NorFor (2001), CVB (2016)..... - 13 -

Table 5: Main categories, objectives and question type of the survey aimed at the French dairy heifers advisors..... 17

Table 6: Example of dairy heifers' diet for large dairy breed, with AFC between 28 and 30 months 18

Table 7: Categories and unity of the French survey aimed to dairy heifers' advisors 19

Table 8: List of French experimental unity that will be contacted to collect dairy heifer's data, with their main sector and localization 20

Table 9 : Variables for the comparison of dairy heifers diets collected and the results of the INRation diet software calculation..... 21

Table 10: Main categories, objectives and question type of the survey aimed at the French dairy heifer advisors 21

Table 11: Linkedin groups for the share of the survey 22

Table 12: List of variables researched in the literature study 23

Table 13: Table 13: Number of farms followed by each advisors 24

Table 14: Quantity of DMI per heifer for 3 ages of heifer with 2 different main forage in the diet proposed by respondents 29

Table 15: Description of experimental farms having a dairy business in France 30

Table 16: Number of group of heifers with intake group measurement, depending on the main forage of the diet 31

Table 17: General characteristics of the sample: 32

Table 18: Overview of data collected on dairy experimental farms, depending on average BW of dairy heifers. 33

Table 19: Share of the main forage in the diet 35

Table 20: Main diets characteristics of heifer groups 37

Table 21: Dairy heifers DMI according to studies from literature from other countries 41

Table 22: Comparison between data from French experimental farms and literature from other countries 42

Table 23: Matrix between heifer BW and hay quality. Output: DMI 46

Table 24: Matrix between heifer BW and hay quality. Output: ADG 47

INTRODUCTION

Production costs in dairy farms depend on many factors such as feeding, renewal rate, energy costs and they also include the rearing cost of dairy heifers. Dairy heifers are of crucial importance since they will be cows, producing milk. Good management from birth until calving, to ensure adequate growth performance at a reasonable cost. Feeding in most dairy farms represents almost ¾ of the operating expense (Chambre de l'agriculture des Pays de la Loire, 2018), and it also includes, feeding of heifers.

Most objectives and practices about rearing heifers are driven by the age at first calving (AFC) objective in many dairy farms. The feeding system is then targeted towards a specified age at calving, with avoidance of nutrient shortage or excessive growth (fattening), which can also generates extra-costs. (Institut de l'Elevage, Guide pratique de l'alimentation du troupeau bovin laitier, 2010).

Dairy farmers usually pay more attention on adult cow nutrition since milk production is their main income. They do not realize the importance of rearing, and according to Henry and Morrison back in 1915, “The rearing of the heifer after 6 to 8 months of age is an easy task, and perhaps because of this many are stunted for lack of suitable feed.” However, the importance of heifers rearing led to a large number of researches and studies over the past 100 years, about AFC, colostrum intake, growth, fertility and many others aspects. Feeding is related to many subtopics like growth or average daily gain (ADG), body development and/or voluntary feed intake. In this later case, most studies focusing on feed intake have been published before 1986 (Heinrichs, 2017) and according to some French dairy advisors and farmers, current heifer feed intake capacity is higher than predicted by commonly used models. Feed intake capacity is important to quantify precisely and efficiently feed ration inputs, which drive growth performance.

In France, the French National Research Institute for Agriculture, food and Environment (INRAE) established a feeding system for ruminants and published several updated versions since 1970, to take into account the scientific new understanding and the evolution of the general context of dairy industry (1978;1984;2007;2010;2018). In 2007 a diet calculation software called INRation was created and largely used in commercial farms. Recently, a growing concern about its capacity to correctly estimate the intake capacity of modern dairy heifers emerged. The rise of milk production, the change in feed intake capacity and more

generally the genetic improvement of animals and plants used for feeding were regularly considered in adult cow's diet calculation, but not in heifer's one. It was then hypothesized that changes in heifer size and age at puberty attainment did change according to genetic selection. If the cow feed intake increased, it is reasonable to think that feed intake capacity of heifers also changed. The arising question was then:

Are the algorithms used to calculated heifer's daily intake requirements updated due to underestimation of feed intake capacity?

This question was asked by the French Livestock Institute (IDELE) in partnership with INRAE, who both wanted to improve, if necessary, the feeding system used in France. The answer is important for the dairy sector, particularly researchers, dairy nutritional advisors and dairy farmers. An update of this specific criteria, if needed, will lead to a better efficiency in the heifers feed diet calculation and will have many positives consequences, related to the animal itself, the farm daily feeding cost or other global aspect (better use of feed will reduce environmental impact for example).

To respond this question, the project "INGELA" (Ingestion des Génisse Laitière = Dairy Heifer Intake) was settled down by IDELE and INRAE, including 2 steps:

- An overview of the situation on dairy sector and individual measurements of dairy heifers' intake on experimental farm in France.
- An inquiry on the practices available on experimental and commercial farms

The experiment currently done on the Pin au Haras farm in Normandie is intended to respond to the question: What is the current dry matter intake of dairy heifers?

Present report is focusing on the overview of the situation and practices available. First of all, it is dedicated to what influence dairy youngstock intake under several points of view: animal, feed, and environment perspectives. Secondly, dairy advisor experiences and dairy heifers recommendations is highlighted, and last, a deepening of the heifer intake topic is performed, with the introduction of different intake predicting systems from other countries.

DEFINITION

Intake in ruminants depends on the ability to intake a certain amount of feeds, which results from its energy and protein needs, motivation to eat and ability to digest. That is called intake capacity (IC). It only depends on animal characteristics (INRA,2018). Concretely, the animal expresses its own IC by its voluntary feed intake. Because to formulate diet dry matter (DM) unit is used, it is also commonly called dry matter intake (DMI). The main difference between IC and DMI is that IC is taking account only animal parameters rather than DMI depends on animal characteristics, chosen feed and diet composition, farm management and environment. For the same chosen ruminant, IC remains the same but its DMI will vary principally with feeds ingestibility.

FACTORS AFFECTING DMI: ANIMAL FACTORS

PHYSICAL REGULATION OF FEED INTAKE

The main factor affecting DMI is the energy requirement which depends on ambient temperature, physical activity and growth. Requirements and intake capacity also vary according to breed. Some cattle breeds are called early-maturing or late-maturing breed, body development is faster for early-maturing breed, and because the appearance of puberty depends on the BW (around 40-50% of the adult BW), the age at puberty change: between 9-10 months for Holstein heifers and 13-14 months for Montbeliard heifers. The same phenomena exists for small and large breed, Jersey heifers do not have the same BW as Holstein heifers with same age. Also, rumen development is closely related to body development and feeding management at young age, heifer's need at the same age is not the same depending the choice of rearing management (Institut de l'Elevage, Guide pratique de l'alimentation du troupeau bovin laitier, 2010). It thus follows that DMI is more related to BW than the age. DMI increase linearly with BW gain, body condition score (BCS) and fatness (Quigley, 1986). Adding to BW, because the DM has the capacity to fill the rumen, the rumen size is a physical regulation of feed intake (Khan, 2016). In the French dairy farms, weighing animals is not widely used due to time constraints, availability of restraint and weighing equipment, cost of service or investment of a scale (Houssin, 2012).

PHYSIOLOGICAL REGULATION OF FEED INTAKE

Ingested feed in the rumen is largely undigested. The rate of the rumination processes varies with the general fermentation activity and the rate at which the particles are progressing

through the digestive tract. Some factors influence the fermentation process: the particles size, the energy brought to the rumen microbiome, and the amount of nitrogen available for rumen microbes. Any variation of these factors results in a change in the feed intake (INRA, 2018).

The control of feeding behaviour comprises many intern factors and is complex. It includes stimulatory and inhibitory signals, between brain feeding centres and some organs like the liver or the rumen, metabolic control feeding has also an impact on feed intake (votality fatty acid concentration of the rumen for example) (Allen, 2014).

GENETIC

Heritability is a genetic parameter that measures the share attributed to genetics in the variability of the performance of a given population. In a study using intake data from dairy cows and their heifers from 9 countries, the feed intake heritability for dairy heifers ranged from 0.20 to 0.34, so the variation in intake capacity is moderately heritable. Moreover, the genetic correlation between lactating cows and heifers was 0.67 (Berry, 2014).

FACTORS AFFECTING DMI: FEED FACTORS

DIRECT FACTORS

A decrease in feed intake is generally the result of an increase of the fill value (FV) of the forage. The FV is different for each forage and characterizes the ability of a forage to fill the animal's intake capacity (Institut de l'élevage, 2010). In the INRAE feeding system, the “fill unit” (Unités d’encombrement, UE) gives one single value to the IC of each category of animal, regardless of feed, and one value to the ingestibility of the forage. This system is based on young pasture grass with values, on a DM basis, of 25%, 15% and 0,77 for crude fiber, crude protein, and digestibility organic matter respectively. One kg of DM of this young grass also has a one UE value. Methods to calculate forage FV is based on the digestibility of the organic matter on sheeps. It is the reference method for fresh or conserved forage and straw digestibility calcuation because sheeps have almost the same digestibility as cows (INRA, 2018).

DMI of the diet = forage DM * forage FV + Concentrate DM * concentrate FV

In other feeding system, the neutral detergent fiber (NDF) is used like a predictor of voluntary intake (NRC (2001); NorFor (2011). The NDF digestibility of the forage can be measured in two ways.

- *In situ:* In this case, NDF digestibility is estimated by using small bag inserted into the rumen of a cow. This method is good, but the database is limited in the number of observations.
- A 48 hours in vitro NDF digestibility. Developed by Georing and Van Soest (1970), the NDF digestibility is obtained by incubation into a glass flask. With this method, the NDF digestibility of forages is more important.

As the plant grows, its internal composition evolves and the older it gets, the more its composition in NDF increases and the cell content decreases. NDF is important because it provides 50% of the digestible energy for the animal. NDF is also characteristic of the forage fill value. Fiber concentration in the feed, which is related to NDF concentration is the most slowly digested part of the feed. NDF components have all a different digestibility, and the proportion of these NDF components influence the global digestibility. For example, the more lignin there is, the less digestible the forage will be. NDF digestibility varies with factors like feed maturity, species, growth conditions, harvesting conditions, storage type. When NDF in % increases, DMI decreases (Van Soest, 1967). More concretely, the choice of feed in the ration impacts the DMI. For example, an increase in the share of straw (with a high NDF concentration) in the diet makes DMI decreasing (Greter, 2008).

Plants species and varieties have influences on NDF content (*Figure 1*). Legumes are ingested in greater quantities than grasses (about 20%) with a lower NDF content. As well, there are differences in ingestibility between grass species at the same age (Hoffman, 2001).

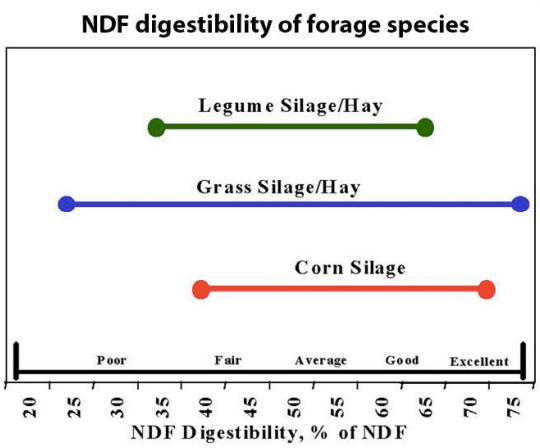


Figure 1: NDF digestibility of forage species (Hoffman, 2001)

The modes of production, nitrogen fertilization, phospho-potassium or organic, harvesting and storage methods influence composition the plant and then its ingestion (Ball, 2001).

INDIRECT FACTORS

Heifers like mostly cattle can choose feeds if allowed, meaning they had preferences for some of them. This depends on forage type and its storage (use of additive or not), smell and "freshness". Fodder distributed 3 days ago is less palatent than the one distributed today (Akdag, 2018). According to Faverdin et al. (1995), a satiated animal can eat more if fresh forage is presented.

Time spends in the rumen also influences intake: the slower the digestibility, the longer it remains in the rumen and therefore the less the animal ingests. The size of the ingested particles plays an important role: a smaller particle size increases DMI, decreases the digestibility of the feed as well as rumen solids retention time (Akdag, 2018).

Another important factor is the substitution process between forages and concentrates. The substitution rate forage/concentrate varies with the forage quality and the amount of concentrates in the ration (Huhtanen, 2008). But more precisely, it is the fill value of the forage and concentrates share in the diet which determines this substitution rate (INRA,2018).

FACTORS AFFECTING DMI: ENVIRONMENTAL FACTORS

REARING STRATEGY

Farmer’s age at first calving (AFC) objectives determine feeding and growth management of his heifers. This choice is depending on several factors such as breed, location, availability in

forage/pasture, housing conditions and/or calving season. AFC varies between 2 and 3 years old, the actual trend being to lower this age. Calving season plays also a role in the feeding strategy: opting for group calving allows a collective feeding plan for all the herd and can lead to a better efficiency of the ration because heifers have the same age, compared to calving spread over the year. Based on AFC and mature BW, the feeding strategy is adapted to animal size and the expected average daily gain (ADG) (Institut de l'Elevage, Guide pratique de l'alimentation du troupeau bovin laitier, 2010).

Table 1: Prediction example of intake for Holstein dairy heifers, depending on their age and the AFC objective (Chambre d'agriculture Meurthe et Moselle, 2014)

	AFC	**24 months**	**30 months**	**36 months**
Age, months (BW)	ADG (g/day)	Forage kgDM/d + Concentrates kg Gross/d		
6	750	5.5+1.7		
(± 200kg)	600		5+1	
	450			4.5+0.5
12	800	8+1		
(±300kg)	500		7.5+0.5	
	450			7
18	850	10+1		
(±450kg)	700		9+1	
	450			8,5
21	-	-		
(±520kg)	700		10,5	
	450			10

FEEDING METHODS

During the transition from liquid (milk) to solid feeding, the composition, physical form and amount of the calf starter diets affect the rumen development. Forage and starter given in sufficient amount are necessary for motility and fermentation, as well as salivary gland

development. The choice of forage and concentrates provided is then determinant (Khan, 2016). Feeding frequency or method (mixed ration or not) and meal size influence DMI (Allen, 2014). Depending on the calving season, winter feed costs and management differ (IDELE, 2018).

Moreover, during winter, when animals are indoor housed, the barn, the reduction of feeding allowance is usually performed to decrease feeding costs, and benefit of compensatory in growth while turning back to pasture next spring. The compensatory growth phenomenon can be explained by the increased intake and a better animal feed efficiency (Institut de l'Elevage, 2020).

CLIMATE / ATMOSPHERE

The general climate, housing conditions, competition at the feed barn and many other environmental factors can result to an increase or decrease on DMI (NRC, 1981). Also, adequate feeding space, social order among heifers make DMI variation (Betchel, 2018).

ACTUAL DATA AND MODELS OF INTAKE PREDICTION

In practice, dairy heifer intake is estimated from diets available on the literature which are already ready to be applied or from predictions existing in feeding systems.

EXAMPLE OF RATIONS DURING WINTER PERIOD

The literature gives some examples of dairy heifers diet practiced on dairy farms, as in France for example (***Erreur ! Source du renvoi introuvable.****2*), classified by main forage.

Table 2: Number of dairy heifers diet found from non-scientific references: farmers' association, breeding advisoring company

Main forage of the diet	**Number of diets**
Hay	26
Grass silage	15
Bailed silage	1 - As the process is similar to that silaging, this will be integrated with the grass silage diet

Straw	12 - Dry rations as an alternative of the forage diet, with a diet based on concentrates
Corn silage	13

Sources are listed on figure 2.

Rearing heifers is usually composed of different stages of growth, which result in different rations. A survey was conducted by Web-agri, an online magazine: from 23 to 31/03/20 on heifers feeding strategy and 830 farmers participated. When asked "What is the main forage for your dairy heifers over one year old?" 55.8% of them answered hay and bailed silage, 17.2% grass silage, 15.8% corn silage and 11.2% straw (Scohy, 2020). Although the results of this survey are only indicative, it confirms the fact that the use of hay, bailed silage and grass silage is mainly used in heifer rearing.

These diets are carried out according to heifers BW and the objective of ADG. Depending on these objectives, hay and grass silage are associated with concentrates like wheat, grain, and soya meal. The amount of concentrates is related to the heifers BW, ADG and forage quality.

In the following example (*figure 2)*, because of the grass silage quality, there is almost no concentrates added in the diet, only for high growth objectives and bad silage. For hay diet, the median is equal to 1.2 kg gross with 0 kg gross as minimum and 1.9 kg gross as maximum.

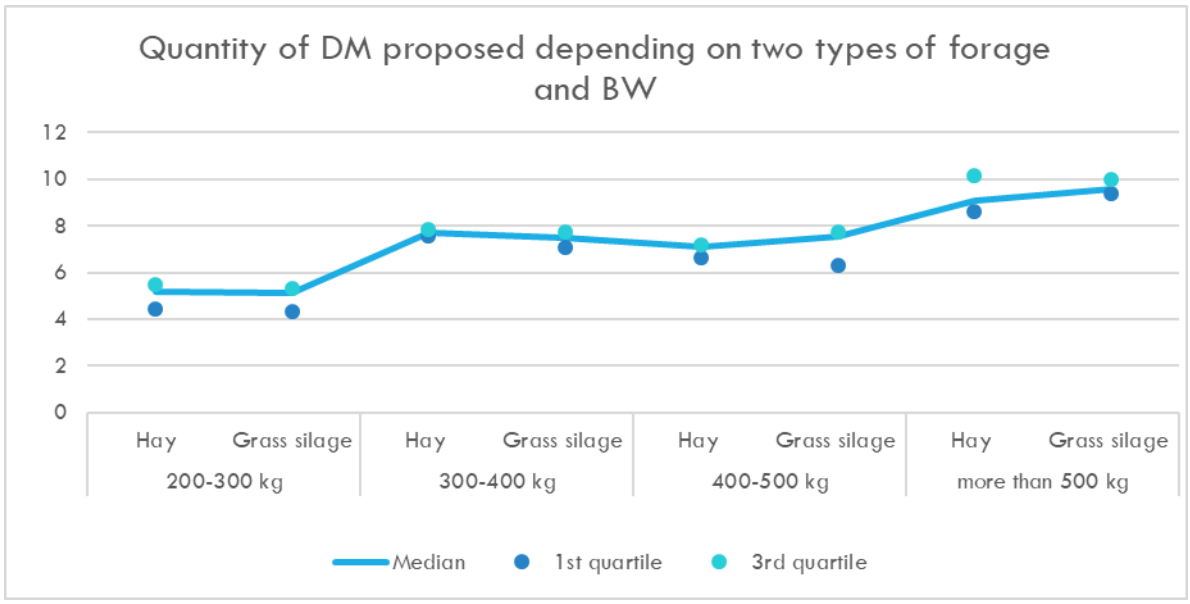


Figure 2: Adapted from different sources, « De l'herbe récoltée pour alimenter les génisses laitières, Chambre d'agriculture Nord-Pas de Calais (2010), Itinéraire technique génisses Prim'Holstain, Chambre de l'agriculture Meurthe et Moselle (2014), Alimentation minérale des génisses laitières : Optimiser l'apport de minéraux, Chambre d'agriculture Bretagne (2008), Génisses laitières, moins de tracas, plus de résultats, Chambres d'Agriculture de Bretagne (2017), Utiliser des aliments fermiers pour élever les génisses, Institut de l'Elevage (2017), Alimentation des génisses laitières : Foin, enrubannage, ensilage ou paille : quelle ration choisir ? Vergonjeanne (2015), Les jeunes femelles d'élevage : un capital à faire fructifier, Institut de l'Elevage (2014)

In these examples, it can be noticed that the DMI increased with the BW, but the amount of DM ingested varies for the same BW and with the same type of forage. The amount of concentrates depends on the ADG. When the ADG is above 700 g/d, the amount of concentrates is above 1.2 kg gross in the diet. For an ADG under 500 g/d, there is no concentrates in the ration. It depends also on the type of forage, most of the diets with grass silage has not concentrates, but it is mainly associated with hay. As well, when the ADG wanted is high, the DMI of forage decreased with an increase of the concentrates.

INTAKE CALCULATION PREDICTION

Table 3: Equation of DMI prediction from 4 different feeding systems. Based on INRA (2018), NRC (2001), NorFor (2011), CVB (2016)

Feeding system	**Equation of prediction**
INRA (2018)	$IC = BW^{0.90} * I_{type}$
NRC (2001)	$DMI = BW^{0.75} * (0.2435*NE_m – 0.0466* NE_m^2-0.1128)/ NE_m)$

NorFor (2011)	IC_heifer = $\left[0.007236 * BW + 0.0005781 * ADG + \left(\frac{-3}{0.9552 * BW}\right)\right] * IC\_gest$ IC_gest = $\frac{1}{1+e^{((gest\_day-357)/36)}}$
CVB (2016)	There is not equation of heifer intake prediction available, there is only a table with intake benchmarks

Where: BW = body weight in kg; NEm = Net Energy of diet for Maintenance in Mcal/kg; ADG = average daily gain in g/day; IC_gest = gestation correction on IC for heifers; gest_day = day of gestation

All the predicting systems are based on knowledge about physical and physiological limitations for DMI of dairy heifers (*table 3*). They do not consider the feed characteristics. In this way, heifer intake prediction can be used for various feed ingredients which complete the diet.

NRC's Nutrient requirements of dairy cattle (2001) is a net energy system developed for North America by the National Research Council based on Holstein data. The 8th edition is going to be published soon. The equation for beef calves from the Nutrient Requirements of Beef Cattle (NRC, 1996) is recommended for predicting DMI of growing, nonlactating Holstein heifers. The NRC (2001) DMI equation is using NEm (Net Energy of diet for maintenance), and BW. There is no adjustment for gestation, and according to Hoffman et al. (2008), DMI is underpredicted for light heifers (<275kg) and overpredicted DMI of heavy heifers (>490kg). The share of the BW is predominant in this system, the NEm is an independent variable. However, the NEm decrease when the BW increases, so the NEm is dependent of the BW for older heifers.

The French feeding system for ruminants is developed by the INRAE. The latest version was updated in 2018. Some improvements were made, particularly an update of the equation of DMI prediction for dairy cows. For dairy heifers, the calculation and benchmarks are from the 1988 version. In *table 2*, the BW is prevalent for the DMI prediction. The results are expressed in UE/day (Unité d'encombrement), which is the fill value unit in this system. By definition, 1 kg dry matter (DM) of a reference young pasture grass has a "fill value" (FV) of one fill unit both in sheep (1 UEM) and in cattle (1 UEB). Each animal categories defined by sex, BW, level of production and other factors has a feed IC expressed by one single value

(UE) regardless of the feed given. Forage given alone, the expected voluntary DMI is equal to the intake capacity. For heifers, the IC evolves with the increase of the BW, a coefficient equal to 0,9 is added to follow this progress. The variable *Itype* incorporates some factors like the breed, the sex, if it is a young animal or animal for finishing. For heifers, the *Itype = 0,039* for heifers with a BW > 300kg (INRA,2018). As BW increases, IC increase but slower : IC increase of 40% for BW range from 200 kg and 300 kg, meanwhile it is an increase of 30% for BW range from 300 kg and 400 kg (Institut de l'Elevage, Guide pratique de l'alimentation du troupeau bovin laitier, 2010).

NorFor (2011) system hypothesized that strong correlations between feed and animal characteristics affect predictive feed intake models for growing cattle. Here, IC = FV_intake, where IC is expressed in fill units/day and FV_intake is the diet fill value expressed as fill units/day. In ths equation, BW, ADG in g/day, and gestation stage of the heiferare taken into account on the intake prediction calculation. The FV of forages in NorFor is based on organic matter (OM) digestibility and NDF concentration. It is the only system that integrate the gestation correction and day of gestation on IC for heifers. (Volden, 2011).

In the Dutch system (CVB, 2016), no predictive equation for dairy heifers intake is available. It just gives the requirements for the daily intake. These benchmarks remain the same as the

		VEM/kg DM roughage					
		450[1]			750		
BW (kg)	Growth (g/day)	GDM	Roughage (kg DM/day)	Concentrate	GDM	Roughage (kg DM/day)	Concentrate
100	850	-	-	-	2.4	1.4	2.0
200	850	3.0	1.9	3.3	4.2	3.6	1.5
300	700	4.2	3.3	3.6	5.6	5.1	1.3
400	625	5.2	4.3	4.2	6.7	6.2	1.5
500	500	6.0	5.3	5.1	7.7	7.2	2.1

		VEM/kg DM roughage					
		850			950		
BW (kg)	Growth (g/day)	GDM	Roughage (kg DM/day)	Concentrate	GDM[2]	Roughage (kg DM/day)	Concentrate
100	850	2.8	1.5	1.8	3.2	1.6	1.6
200	850	4.7	4.6	0.2	5.2	4.3	0.0
300	700	6.1	5.9	0.0	6.6	5.3	0.0
400	625	7.3	7.2	0.0	7.9	6.4	0.0
500	500	8.3	8.2	0.4	9.0	7.8	0.0

1) Wheat straw.
2) In pastures of 950 VEM/kg DM, the gross DM intake is 10% higher than the forages intake indoor.

Figure 3: Gross DMI from roughages (GDM) and net roughages intake in kgDM per animal per day with matching concentrates supply (app. 90% DM and 940VEM) in kg/animal/day, for indoor-fed young stock, depending on BW, desired growth rate, and VEM content in the roughages (CVB, 2016)

feed table for ruminants done in 2008 (CVB, 2008).

Figure 3 shows DMI for heifers depending on the BW, ADG, roughage, share of the concentrate in the diet and the energy content of the diet (VEM/kg DM roughage). For equivalence between these prediction systems, approximately 1000 VEM = 1 UFL (french energy unit) = 6,9MJ Nel (Net Energy Lactation) =1kg of barley (Sundstol, 1993).

Table 4: List of variables of DMI equation of prediction from INRA (2018), NRC (2001),

Feeding system	**Variable of the DMI equation of prediction**	**Variable in common**
INRA (2018)	BW; Itype	BW
NRC (2001)	BW; NEm	
NorFor (2011)	BW; ADG; IC_gest; gest_day	
CVB (2016)	No equation of prediction, only benchmarks with BW, VEM/kgDM, ADG	

NorFor (2001), CVB (2016)

To conclude, the choice of the BW as a main factor (**Erreur ! Source du renvoi introuvable.** is widely understood, since the rumen development allows a greater DMI with the increase of BW. This physical regulation is predominant, but, physiological, feed and environment factors largely impact the DMI. Feeding system such as NorFor (2011) include the ADG and the stage of gestation. About the CVB (2016), the observation for the benchmarks are old. The other variables indicate that these systems want to be closer to the real DMI of the heifers, to adjust the equation they use different variables related to the animal requirements: Itype, ADG, NEm, and IC_gest.

KNOWLEDGE GAP AND RESEARCH QUESTION

According to literature, DMI of heifers is mainly affected by BW, which is also influenced by BCS and energy requirements. DMI can be explained by physical and intern regulations, but it is also influenced by genetic and environmental aspects, varying from a farm to another one. And finally, DMI is also affected by feed itself, like its NDF concentration.

The four feeding systems describe here, INRA (2018), NRC (2001), NorFor (2011), CVB (2016) have their own method to predict DMI. The only common point among these systems is the BW. These systems of DMI calculation are old, and commercial recommendations appear to be approximate and sometimes inconsistent. Because it is more difficult to estimate actual intake of grazing heifers, this study will be focused on winter diets. It is not yet known if French current heifers intake is still in accordance with the intake prediction systems. This is important to know because mistakes on heifers feeding lead to excesses and shortages which generates extra-costs and unwilled errors such as insufficient BW or too fatty animal, which have a global impact on heifer rearing strategy like AFC. An update is needed, therefore the research question is:

What is the accuracy of French estimates of DMI of dairy heifers on a winter diet based on dairy advisors experiences, farms data and recommendations from other countries?

To answer this research question, the following sub question is asked:

1. How do French dairy advisors opinions and recommendations about dairy heifers intake on a winter diet based position themselves in relation to the French feeding system?
2. Do recent intake measurements in heifers on a winter diet correspond to literature data currently used in French feed formulation software?
3. What are differences in DMI estimates for dairy heifers on a winter diet between France and other countries?

By answering the question, the objective is to know if there is a need to go deeper in the heifer intake analysis. If there will be a need to update heifers intake benchmarks, and if it will be necessary to modify the INRAE model of intake prediction. The statement of this

report will be used further on the INGELA project with the results of the individual measurements dairy heifers

MATERIALS AND METHODS

The research method was led by 3 sub-question. For each, the methods were treated in a SMART way.

HOW DO FRENCH DAIRY ADVISORS OPINIONS AND RECOMMENDATIONS ABOUT DAIRY HEIFERS INTAKE ON A WINTER DIET BASED POSITION THEMSELVES IN RELATION TO THE FRENCH FEEDING SYSTEM?

The main objectives of this survey was: 1) to know current winter diets of dairy heifers on farm, and their intake; 2) to determine the opinion of advisors about dairy heifers intake; 3) to assess differences between advisors responses and intake prediction software.

The data was collected by an online survey (Appendix 1). The main categories and objectives of this questionnaire are included on table 5.

Table 5: Main categories, objectives and question type of the survey aimed at the French dairy heifers advisors.

Categories	**Objectives**	**Question type**
Identity	Who is the respondent? What is his job?	Closed question
Profile	Where is he located? How many farms do you advise? In how many do you make advice for dairy heifers?	Closed question
Feeding practices	What are the main forages use in dairy heifers' diet on the farms you are in charge? Do you use a ration software? In your opinion, how many DM a heifer can ingest per day? Is there a a gap between your diet calculation software and what is done on farms? Do you use the FV of the diet to make dairy heifer diets?	Closed and Open-ended question
Winter feeding diet	Give an example of dairy heifer's winter diet with medium quality hay and medium quality grass silage. Do it for 3 categories of dairy heifers: 6 months, 12 months and	Closed question

18 months.	

This survey was performed using *Limesurvey* and sent to 13 heifer managers or feed engineers. Each of them was asked to transfer the survey to their dairy heifers advisory team and technical-sales team. A one-month delay was given to get back the survey responses. From the e-mail reception, they had 1 month to respond the survey. About 20 minutes was needed to fulfill the inquiry.

Heifers categories chosen in the survey were aged 6, 12 and 18 months old, which are usual benchmarks for rearing heifers. The email also gave information on the aim of the project INGELA, , the leader and partner of the project and explained why their involvement was important and the use of the data.

A short video about the aim of the project INGELA and how the project was conducted was added.

Informations given on the last part of the survey (*table 6*) was used for a comparison with the French feed information software INRation v.4. Descriptive analysis was done to analyze the results of the survey.

Table 6: Example of dairy heifers' diet for large dairy breed, with AFC between 28 and 30 months

Diet ingredients	**6 months**	**12 months**	**18 months**
Hay Medium quality	kgDM/day	kgDM/day	kgDM/day
Concentrate n°1	In kg Gross/day	In kg Gross/day	In kg Gross/day
Concentrate n°2	In kg Gross/day	In kg Gross/day	In kg Gross/day
Mineral	In kg Gross/day	In kg Gross/day	In kg Gross/day
Total of kgDM	kgDM/day	kgDM/day	kgDM/day

The same table was fill for grass silage with medium quality.

DO RECENT INTAKE MEASUREMENTS IN HEIFERS ON A WINTER DIET CORRESPOND TO LITERATURE DATA CURRENTLY USED IN FRENCH FEED FORMULATION SOFTWARE?

The main objectives of this part was: 1) to analyze heifers intake measurement done on many French experimental farms; 2) to determine if dairy heifers intake is the same among these experiment; 3) to assess differences between dairy heifers intake measurements results and the French intake prediction software.

No recent individual intake measurements have been performed on dairy heifers. Information on DMI for group of dairy heifers was asked to French experimental farms if available. An Excel sheet (*Table 7*) was sent to the head of these facilities. The data included collective measurements of dairy heifer intake done during past experiments.

Table 7: Categories and unity of the French survey aimed to dairy heifers' advisors

Categories	Unity	Categories	Unity
Year of the experiment		*Quantity 1st forage*	**Kg DM/day/heifer**
Number of animals in the experiment		*Type of second forage*	
Average BW at the beginning of the experiment	Kg	*DM of the 2nd forage*	**%**
Average age at the beginning of the experiment	Months	*Quantity 2nd forage*	**Kg DM/day/heifer**
Average BW at the end of the experiment	Kg	*Quantity total of forage*	**Kg DM/day/heifer**
Average age at the end of the experiment	Months	*Type of concentrates*	
Type of main forage		*Quantity of concentrates*	**Kg /day/heifer**
DM of main forage	%	*Type of mineral*	
Forage quality		*Quantity of mineral*	**Kg/day/heifer**

This sheet was sent to all French "professional" experimental farms (f@rmXP network) and to INRAE experimental units related to the dairy sector (*table 8*).

Table 8: List of French experimental unity that will be contacted to collect dairy heifer's data, with their main sector and localization

Experimental unity	Main study	Localization
Experimental farm of Trinottière	Dairy sector, Holstein breed	Pays de la Loire
INRAE Mirecourt unity	Organic dairy sector, Holstein and Montbéliard breed	Lorraine, Vosges Plain
Experimental farm of Trévarez	Dairy sector, Holstein breed	Finistère, Brittany
Experimental farm of Blanche Maison	Dairy sector, Normande breed,	Normandy
INRAE Pin au Haras	Dairy sector, Holstein breed	Normandy
INRAE Méjusseaume	Dairy sector, Holstein breed	Rennes, Brittany
INRAE Marcenat	Dairy sector, Holstein and Monbeliard breed	Auvergne, Cantal
INRAE Lusignan	Dairy sector, Holstein	Nouvelle-Aquitaine, Poitiers

As for advisors, the e-mail also included information about the aim of the INGELA project, the leader and partner of the project and explained why their involvement was important and the use of the data.

Descriptive statistics were also used, using SPSS software, to analyze the results of the data collected from the experimental farms.

All diets collected were integrated on the diet calculation INRation v.4.

Some voluntary variation (*table 9*) were performed in a second step (from good to bad for example) in the data set, to study if such an error on the forage FV or on the energy content of the diet (UFL) had consequences on the ADG and DMI and if it led to serious implication or not.

Table 9 : Variables for the comparison of dairy heifers diets collected and the results of the INRation diet software calculation.

Adjustment variable	Objectives	Observed variable
Fill value of the forage (UE) Energy content of the forage (UF)	The aim is to compare diets given on the survey and experimental farms data collection with INRation. The adjustment variable will show if there is an error of diet calculation what will be the consequences.	Growth, ADG DMI

WHAT ARE DIFFERENCES IN DMI ESTIMATES FOR DAIRY HEIFERS ON A WINTER DIET BETWEEN FRANCE AND OTHER COUNTRIES?

The objectives of this last part were: 1) to know intake of dairy heifers of other countries; 2) to determine if there was a difference between French dairy heifers intake and dairy heifers intake from others countries.

An online survey (table 10) was sent to dairy advisor from other countries. As done for the 1st sub-question, the link was sent by e-mail. The entire survey is given on appendix n°2.

Table 10: Main categories, objectives and question type of the survey aimed at the French dairy heifer advisors

Categories	**Objectives**	**Question type**
Identity	Who is the respondent? What is his job?	Closed question
Profile	Where is he located? How many farms do you advise? In how many do you make advice for dairy heifers?	Closed question
Feeding practices	What are the main forages use in dairy heifers diet on your farms? Do you use a ration software? In your opinion, how many DM a heifer can intake per day? Does it have a gap between your diet	Closed and Open ended question

	calculation software and what is done on farms? Do you use the FV of the diet to make dairy heifer diets?	
Winter feeding diet	Give an example of dairy heifers winter diet with medium quality hay and medium quality grass silage. Do it for 3 categories of dairy heifers: 6 months, 12 months and 18 months.	Closed question

For this purpose, a list of potential respondents was done based on contacts (around 15 persons) from EURODAIRY, an European dairy project. The survey was also share on international dairy groups on Linkedin (table 11). It was asked to share this survey to any person that was interested and able to respond. It took around 15 minutes to fill it.

Table 11: Linkedin groups for the share of the survey

Group name	**Aim of the group**	**Number of members**
Global Dairy Innovation Network	This is a global networking group for those interested in all aspects of Dairy Innovation: from Incremental to Transformational, from Processing, Packaging, Product, Promotion, IT to Sustainability.	30 065 members (12th November 2020)
Agriculture	Group for professionals in agribusiness.	154 707 members (12th November 2020)
Agriculture / Agricultural / Agribusiness Professionals - UK & Europe	An Exclusive Networking Group For Agriculture/Agricultural Professionals Throughout The UK & Europe - to	9 530 members (12th November 2020)

discuss news and industry information.	

Next to that, a short literature review was done to compare heifers DMI from other countries and heifers DMI in France.

For the literature research, only scientific documents were used, and some specific variables were chosen (table 12). The dairy heifer diets were detailed and the DMI was informed. The study that was used if not aging more than 10 years. For the French heifers DMI, data from survey and data collection used on previous sub question was used. Only descriptive analysis was performed.

Table 12: List of variables researched in the literature study

	Study	**Heifers age**	**Heifers BW**	**Main forage of the diet**	**Intake**	**Feeding system used**
Unity		*Months*	*kG*		*kgDM/day/ heifers*	

RESULTS

SURVEY AIMED AT DAIRY HEIFER ADVISORS: HOW DO FRENCH DAIRY ADVISORS OPINIONS AND RECOMMENDATIONS ABOUT DAIRY HEIFERS INTAKE ON A WINTER DIET BASED POSITION THEMSELVES IN RELATION TO THE FRENCH FEEDING SYSTEM?

GENERAL INFORMATION

The survey was sent to dairy advisors the 5th of October, and it was closed on the 10th of November 2020. Fifty-five persons looked at the survey but only 21 of them completed the survey.

PROFILE

Most respondents were advisors (19/21), with a consultant and a technical manager. Five companies were represented in this sample: Littoral Normand (9/21), Seenovia (4/21), Chambre d'agriculture (4/21), Conseil Elevage (4/21), Elvup (1/21).

Most of them were located in western part of France (figure 4). They followed on average 37 farms, with a minimum of 15 for the technical manager and the calf consultant, and a maximum of 80 farms followed. A total of 75% of respondents have under their responsibility a maximum of 45 farms.

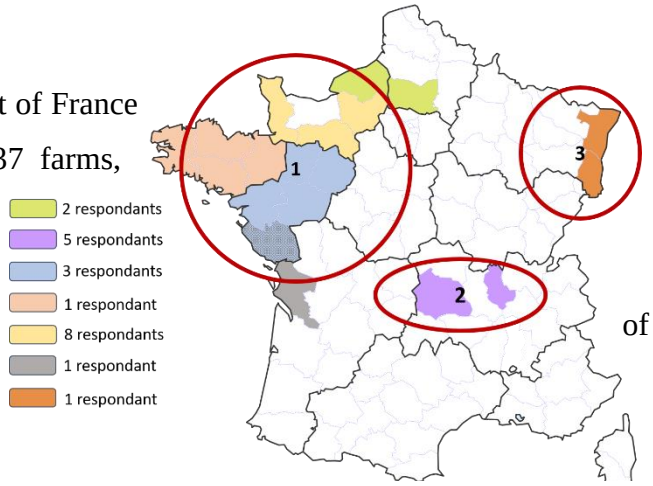


Figure 4: Map of France listing all the respondents

Table 13: Table 13: Number of farms followed by each advisors

Frequency	Number of farm advised per respondant
Minimum	15 farms (1 advisor from Seenovia and one from EDE Puy de Dome)
Maximum	80 farms (1 advisor from Seenovia)
Median	34 farms
1st quartile	30 farms
3rd quartile	45 farms

Thirteen professionals have in their sector more than 75% the same type of breeding. In western part of France, the farms encountered are those in special milk cattle, those in mixed milk and beef cattle for Brittany in particular, Normandy, the Loire countries (1) and Alsace (3) having a majority of farms in polyculture milk cattle. The cattle breed common to all regions is the Holstein. A single advisor has Montbeliarde in these farms (2). The second most present breed was Normande cattle, and 8 advisors had in their sectors other dairy cattle breeds (less than 25%). The predominant AFC is between 24 and 32 months.

MAIN FORAGES USED ON FIELD

Six out of 21 advisors advised on heifers in all the farms followed. For the rest, the first quartile is equal to 31% and the third quartile is 79%. In these farms, on average 52% of farms advised rations for heifers were calculated, with only 4 out of 21 advisors rationing in 100% of the farms followed and 5 out of 21 advisors make less than 15%.

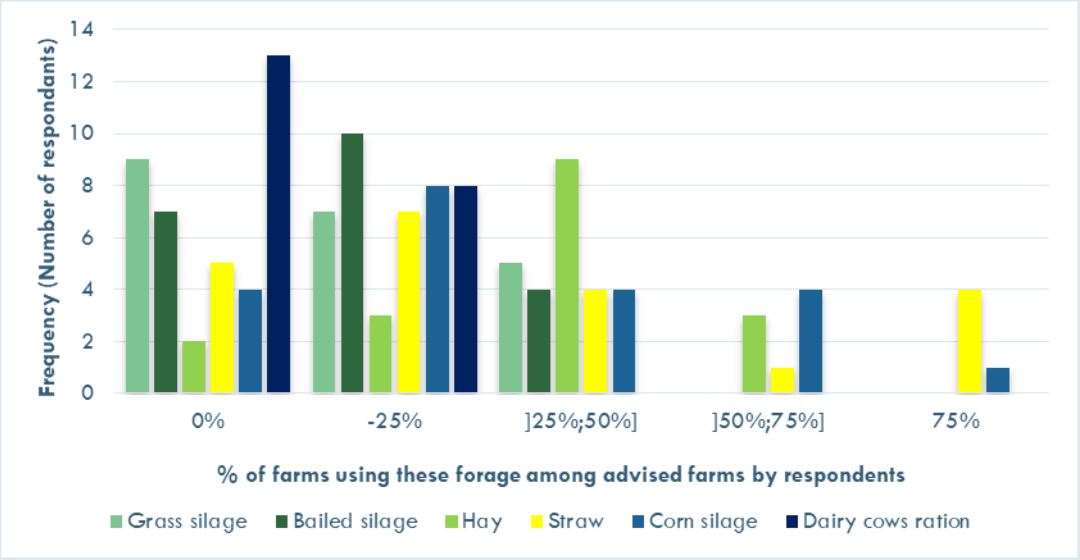


Figure 5: Forage predominance for dairy heifers aged between 6 and 12 months

According to the answers (figure 5), forages used for dairy heifers aged between 6 and 12 months are hay, straw, and corn silage. Grass silage and bailed silage are less integrated to the diet. Refusals of the cow ration are almost not used for this heifer category.

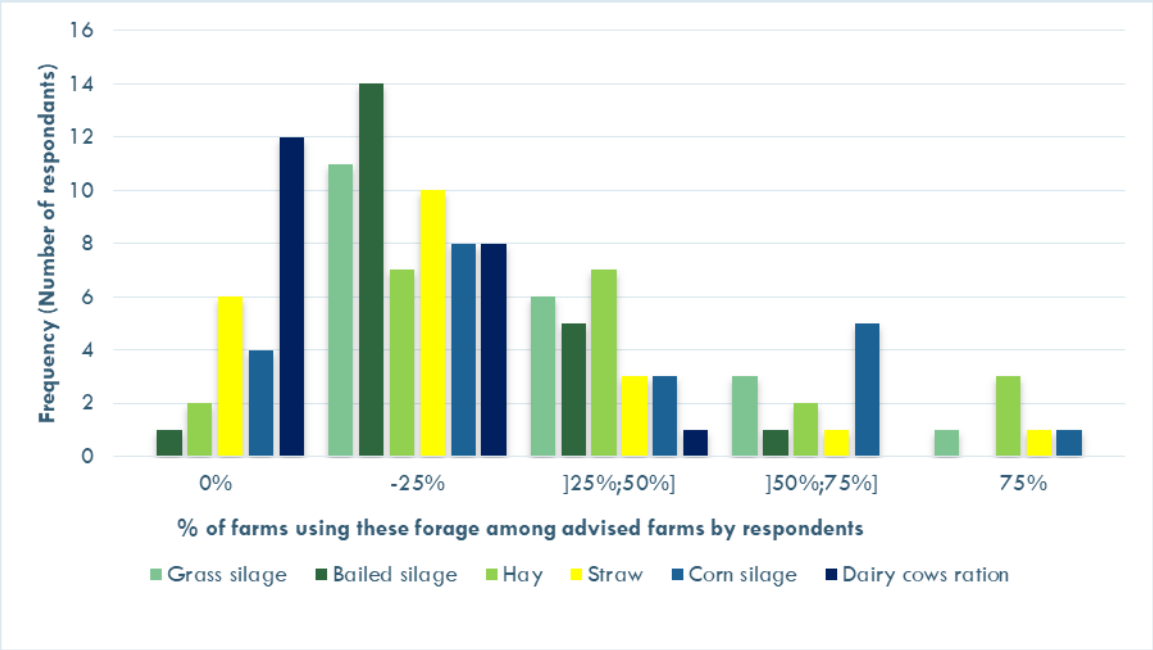


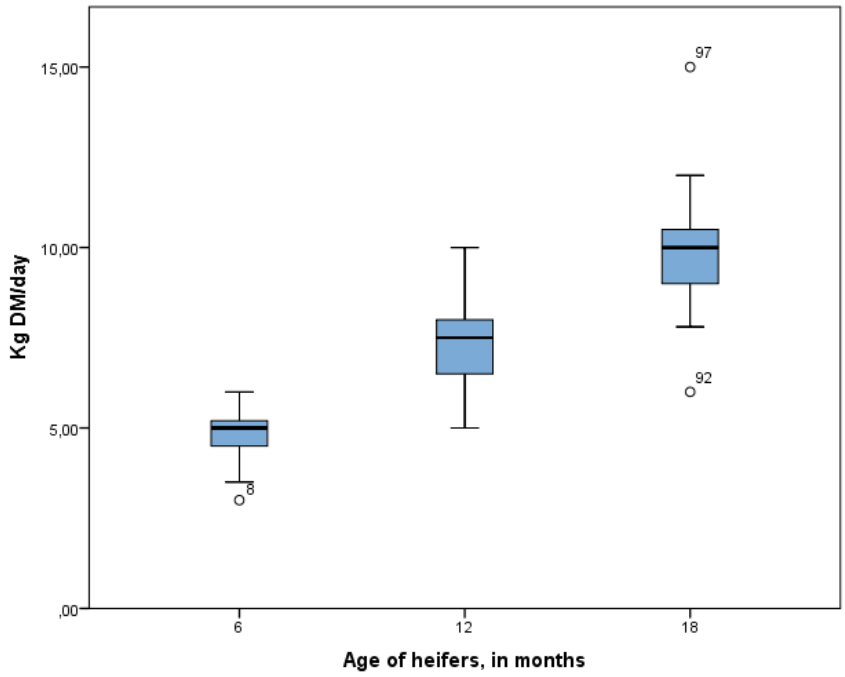
Figure 6: Forage predominance for dairy heifers aged between 12 and 18 months

For heifers aged between 12 and 18 months, corn silage, grass silage, bailed silage, and hay were widely used (figure 6). Straw is less used for the older dairy heifers and cow rations are not commonly used as well. As the two previous graphs can show, there is no one single forage which stands out, but several forages are used for rearing dairy heifers. The specificities of breeding in mountainous regions (center of France) mean that the forage mainly used is hay, while for the other regions of France represented the type of forage is more variable.

DAIRY ADVISORS ESTIMATION

For dairy heifer diet calculation, 10 out of 21 use the diet calculation software from INRAE (INRation), 10 advisors use another diet calculation software like OpRation or an Excel sheet and only one do not use software, he does diet calculation manually because his software does not satisfy him for this type of dairy heifer diet.

Of those who use diet calculator software, 16 out of 20 people think that it correctly predicts the dairy heifers' intake. Three of them think the software underestimates intake, and only one thinks it overestimates dairy heifers' intake.



8 : 3kgDMI

50 : 6kgDMI

55 : 15 kgDMI

Figure 7: Advisor's estimations of heifers DMI for 3 different ages

For each heifer categories, the variation between minimum and maximum of DMI estimate by advisors varied from simple to double: 3 to 6 kg DMI, 5 to 10 kg DMI and 6 to 15 kg DMI for heifers aged to 6, 12 and 18 months in that order. There are also some extreme variables, like 3 Kg DMI for 6 months, 6 and 15 Kg DMI for heifer aged of 18 months. Responses given by the advisors are quite spread. They gave these answer in two ways: by responding on a feeling (11/21) or by using a diet calculation software (10/21).

When they do diet calculation, 15 out of 21 respondents use forage FV, because it allowed to better predict stocks but more important it was needed to determinate intake of the animal, with in particular grass silage and bailed silage. For the other respondents (6/21), they counted on the BW of the animal, using intake benchmarks. One of the advisors did not use this forage FV but he did not know how to use this data.

Differences between advice and diet used in farm differ occasionally for 12 people out of 21. As heifers were weighed only in one farm, heifer BW is then estimated in almost all cases and farmers made their own correction. Non-grouping calving does not permit to make homogeneous groups of heifers during rearing. Another reason is the machine used for feed distribution, the use of a scale or not make a difference on the amount of feed distributed to the heifers.

Eight of them said there was always a difference, due to free availability of the forage which are rarely analyzed. Farmers are also using different forages with different values and distribute feed for several days at the feed barn, so they adjust the diet approximately. The last one said that there are no differences.

WINTER DAIRY HEIFER DIET ACCORDING TO THE RESPONDENTS

Graphs on the figure 8 are the average diets propose by the advisors, answering the question: Can you describe a winter diets that you could advise for large dairy heifers, with an AFC between 28-30 months, with medium quality hay and grass silage as main forage?

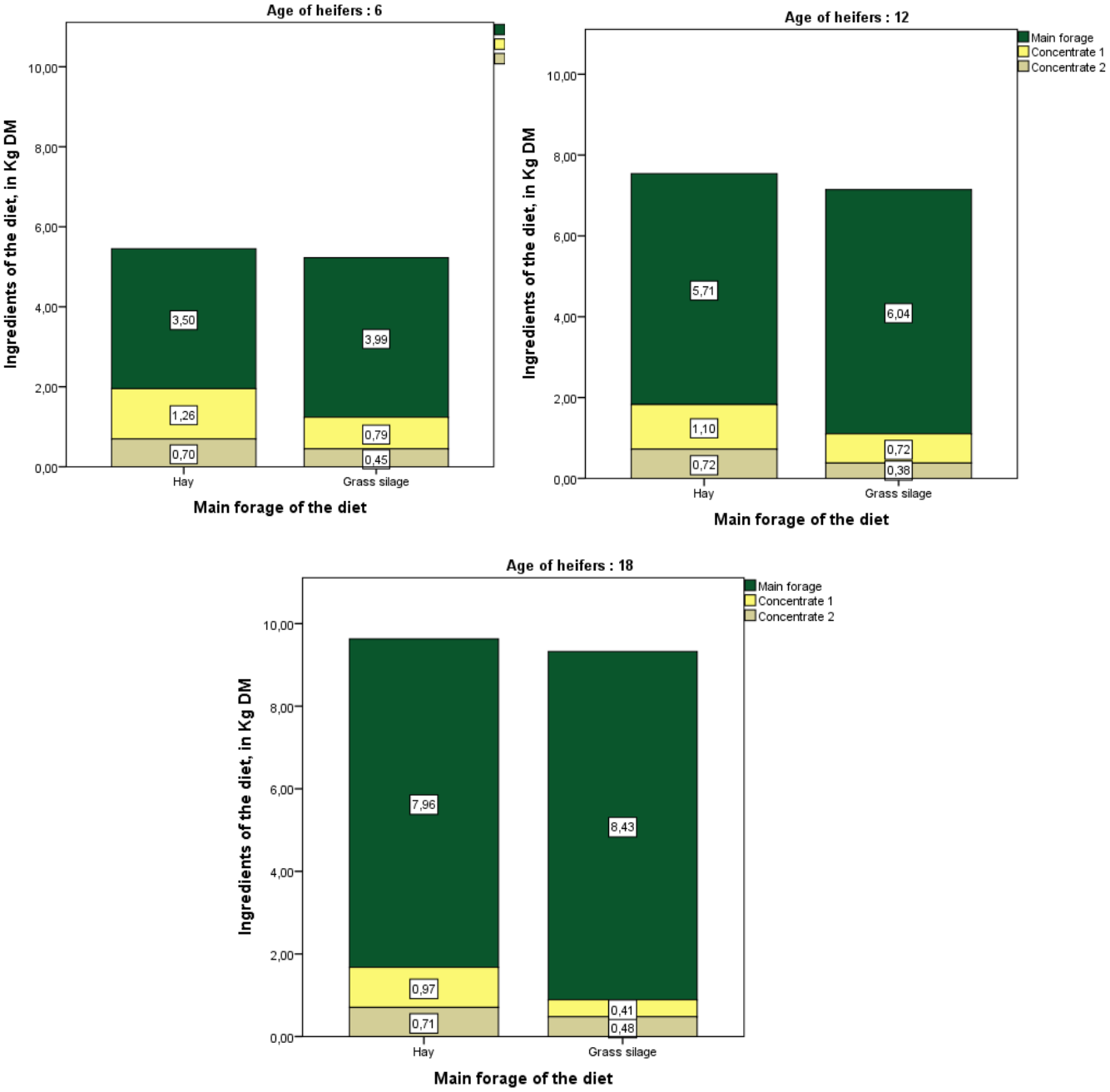


Figure 8: Composition of dairy heifer diets aged of 6 months, 12 months, and 18 months proposed by respondents

Quantities of concentrates were given in Kg, and a coefficient of 89% of DM was applied.

For hay-based diets, advisors propose diets composed on average for the ages of 6, 12, 18 months, respectively of 3.5, 5.7 and 7.9 Kg DM of hay per day, et respectively 1.96, 1.82 and 1.68 Kg DM of concentrates per day.

For grass silage-based diets, advisors propose diets composed on average for the ages of 6, 12, 18 months, respectively of 4, 6 and 8 Kg DM of grass silage per day, et respectively 1.24, 1.1 and 0.89 Kg DM of concentrates per day.

Regardless of the age of the heifer, DMI is superior for a hay-based diet compared to grass silage. The share of concentrates is also higher for hay-based rations.

Table 14: Quantity of DMI per heifer for 3 ages of heifer with 2 different main forage in the diet proposed by respondents

Age of heifers	**6 months**		**12 months**		**18 months**	
Main forage of the diet	Hay	Grass silage	Hay	Grass silage	Hay	Grass silage
Minimum	4	4	5.8	5.3	6.8	6.7
1st quartile	5	4.7	6.7	6.5	8.5	8
3rd quartile	6	5.7	8	7.9	10.2	10.2
Maximum	7	7	10.1	10.1	15	15

Between the 1st and 3rd quartile for hay-based diets for each heifer category, the gap is around 20%, and 25% for grass silage-based diets. This gap, for the 2 diets is equal to 1 Kg DM for the age of 6 months, equal to 1.3 and 1.4 Kg DM for the age of 12 months, for hay and grass silage-based diets respectively, and equal to 1.7 and 2.2 Kg DM for hay and grass silage-based diets respectively.

Data range from single to almost double for minimum and maximum DMI given by the advisors: 4 to 7 Kg DM, 5.8 (hay) and 5.3 (grass silage) to 10.1 Kg DM, 6.8 (hay) and 6.7 (grass silage) to 15 Kg DM for heifers aged of 6, 12 and 18 months, respectively. Advisors

gave rations with a quantity of DMI with a great variability. On average, DMI is larger for hay-based rations, however some advisors have given the same DMI for both types of rations.

DO RECENT INTAKE MEASUREMENTS IN HEIFERS ON A WINTER DIET CORRESPOND TO LITERATURE DATA CURRENTLY USED IN FRENCH FEED FORMULATION SOFTWARE?

GENERAL PRESENTATION

Besides their experiments, all these experimental produce benchmarks for the French dairy sector and they are the support for training and demonstration for actors of the dairy sector.

Table 15: Description of experimental farms having a dairy business in France

Farms	**Description**	**Size of the facility**	**Number of diets collected – farm code**
Experimental farm: « les Trinottières » *Led by Chamber of Agriculture*	Dairy farm, with experiment program. The aim of this facility is to optimize feed efficiency of dairy cows and dairy heifers. Another objective is to provide sustainable practices to farmers.	• 150 Holstein dairy cows, Holstein 120 dairy heifers. Average milk production per cow: 10 000kg. • Total of 183 Ha: 95 ha of corn silage, 12 ha of cereals, and 78 ha of pasture	39 - TRI
Experimental farm : "Trévarez" *Led by Chamber of Agriculture*	Dairy farm which has worked with the French Breeding Institute since 40 years. Its missions are to study technical operations to decrease carbon print, and to analyse the agrobiology performances.	• 185 Holstein dairy cows and 160 dairy heifers. • More than 1 000 000 kg of milk sold per year • One conventional and one organic facilities • Total of 215 Ha: 110 Ha of temporary pasture, 35 Ha of permanent grassland, 50 Ha of corn silage and 20 Ha of cereals.	10 – TRE
Experimental farm: "Blanche Maison" *Led by Chamber of*	Created in 1972, this dairy farm focused its research on agroecology in addition to these experiments with the aim to gain in	• 88 Normande dairy cows, and their heifers for replacement • Average milk production:	4 – BLA

Agriculture	profitability, in social performance and sustainability.	7 000kg/cow • Total of 104 Ha: 76 Ha of permanent grassland, 20 Ha of corn silage, 8 Ha of grains crop	
Experimental farm: "Mirecourt » Led by INRAE	This facility is focus on organic agriculture. They aim to decrease the amount of inputs and to enhance natural resources.	• 100 Montbeliard and Holstein dairy cows and their heifers • Average milk production: 5 000kg/cow • Total of 240 Ha: 130 Ha of permanent grassland and 110 Ha for rotation between cereals and temporary pasture.	8 – MIR
Experimental farm: "Mejusseaume"	This dairy farm is in charge of performing experiments in the field of dairy farming to evaluate and design new technologies and farming practices that meet the expectations of the dairy sector, consumers and citizens.	• 150 Holstein dairy cows and 150 Alpine goats	5 – MEJ

For each heifer lots, measured data are given for a group of dairy heifers. The average BW of the group is the average BW of the heifer group over the experiment period, with an experimentation duration that is different depending on the groups listed. Intake measurement were done by heifer groups/heifer boxes, with the measurement of feed given and feed removed.

Table 16: Number of group of heifers with intake group measurement, depending on the main forage of the diet

	TRI	TRE	BLA	MIR	MEJ
Hay	10			8	
Grass silage			4		
Bailed silage	7	5			
Corn silage	12	5			5

Straw	4				
Sorghum	6				
TOTAL	39	10	4	8	5

The methods of experimentation of Mejusseaume's farm do not include the weighing of all the forage ingested (straw is offered *ad libitum*, without any measurement), the data of this farm were therefore not retained.

Groups of heifers involved had an average BW equal to 400 Kg, and 15.2 months as average age. Most of heifer groups had an average weight of more than 350 kg and were aged 15 months old or more. Also, most of the groups are between 14 and 16 heifers (table 20).

Table 17: General characteristics of the sample:

	Minimum	***1st quartile***	***Mean***	***3rd quartile***	***Maximum***
Average BW of the groups, Kg	214	354	400	427	455
Average age of the groups, months	7.4	13	15.2	15.9	18.2
Number of heifers in the groups	6	14	15	16	41

All farms provided the requested data in an Excel file. The table below provides the main data on ingestion, ADG, average heifer group weight and group number per weight class. The most represented classes are the weight classes between 350 and 450 kg of BW (table 19).

Table 18: Overview of data collected on dairy experimental farms, depending on average BW of dairy heifers.

Class of average BW of the group	*Min. of Total diet intake*	*Max. of Total diet intake*	*Mean of Total diet intake*	*Mean of Average ADG*	*Number of group of heifers*
200-250	5,2	6,4	5,7	733	5
250-300	5,6	6,7	6,0	555	4
300-350	6,2	7,4	6,7	559	5
350-400	6,9	8,4	7,6	735	15
400-450	6,7	9,7	8,2	639	27
450-500	7,6	9,1	8,4	675	2

Extreme data collected from Blanche-Maison, which could be explained by the fact that the DMI averages calculation was done on the beginning and end of the trial, and not on the totality of the test, so it was not kept in the sample. With intake data from Mejusseaume, a total of 8 of the 66 intake data measured were considered as outliers and were removed from this sample.

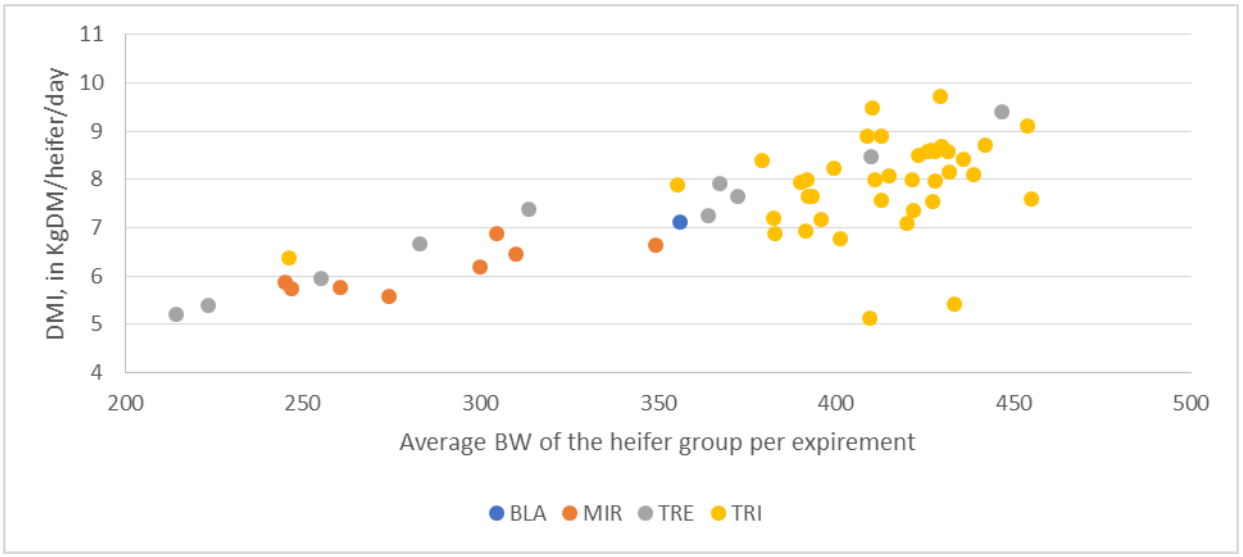


Figure 9: Mean of total DMI per group of heifers depending on the BW average of the heifer group

Total intake per heifer, expressed per Kg of DM, increased with the increase of the BW, regardless of the main forage of the diet. Intake data from TRE are distributed all along the

heifer weight range, between 200 and 450 Kg BW. Those of MIR are divided between 250 and 350 Kg BW, and those of TRI, the farm of which there is the most data, are distributed mainly between 350 and more than 450 Kg BW. Also, data from TRI are more dispersed for the same weight range. Only one data from BLA was kept.

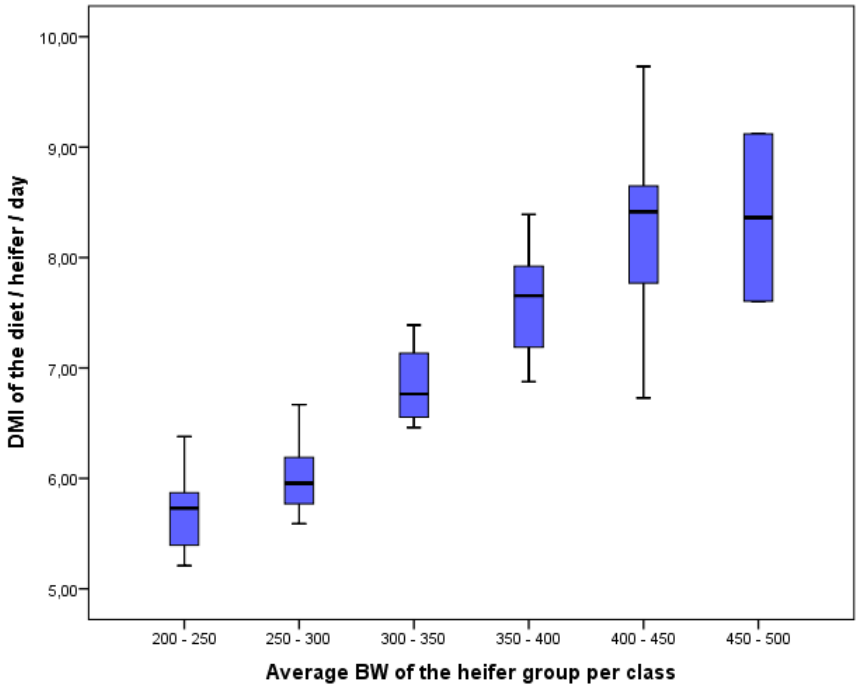


Figure 10: Distribution of DMI per heifer per day per class of BW

Among the classes of weights, the variability of DMI exists, with greater variability for the class 400-450 kg, a class that includes 27 groups of heifers. The variability of the measured data increases with the number of groups of heifers integrated into the class. For the class 200-250 Kg BW, with 5 data included the 1st and 3rd quartile was of 5.3 and 6.1 Kg DM respectively. For the class 250-300 Kg BW, with 5 data included the 1st and 3rd quartile was of 5.7 and 6.4 Kg DM respectively. For the class 300-350 Kg BW, with 4 data included the 1st and 3rd quartile was of 6.5 and 7.3 Kg BW. For the class 350-400 Kg BW, with 15 data included the 1st and 3rd quartile was of 7.2 and 7.9 Kg BW. For the class 400-450 Kg BW, with 27 data included the 1st and 3rd quartile was of 7.6 and 8.7 Kg DM. In the last class of BW there were only 2 data included, 7.6 and 9.1 Kg DM.

Table 19: Share of the main forage in the diet

	Share of the main forage in total DMI	Share of the concentrate in total DMI
Median	76 %	10%
Minimum	26%	0%
1st Quartile	47%	1%
3rd Quartile	94%	11%
Maximum	100%	43%

Among these 58 diets analyzed, diets with less than 50 % of forage in total DMI are essentially those with corn silage as main forage. Indeed, because corn silage has usually a high energy value, this forage is distributed with another forage like hay or straw. Above 50% of forage in the diet, there were hay, and bailed silage diets.

Diets with high share of concentrates, above 33% are diets with straw as main forage. The maximum share of concentrates is about for hay and corn silage 11%, it is 12% for sorghum diets, it is 15% for bailed silage diets, and 43% for straw diets.

The main concentrates used are rapeseed meal (22 diets) and wheat (8 diets). The other concentrates used are soya meal (4 diets), bailey (2 diets), lupin (3 diets), commercial concentrates like VL 2.5L (2 diets). There are no concentrates on 15 diets, 8 hay-based diets, 4 corn silage-based diets and 3 bailed silage-based diets.

Because there is only one diet with grass silage as main forage, it was integrated with bailed silage forage in the rest of the analysis. Also, according to the literature and because heifers are usually fed with grass and corn silage, sorghum and straw diets will be not used in the following.

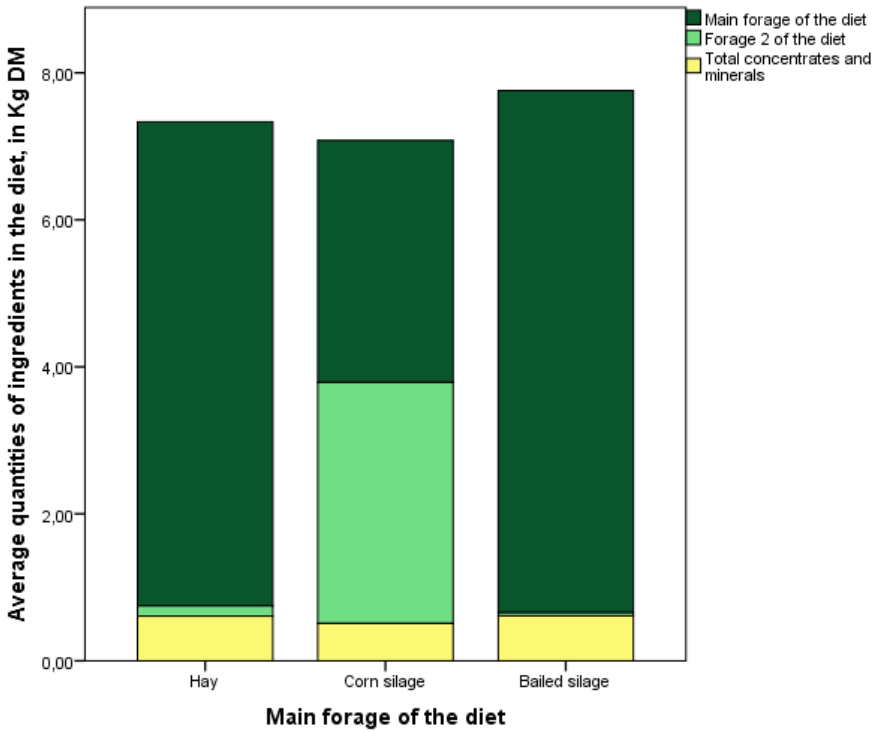


Figure 11: Average quantity of the main ingredients in the diet, depending on the main forage

Heifer diets based on hay, haylage and corn silage do not have the same amount of different ingredients on it (figure 9). There is almost the same amount on average of concentrates for all diets. Also, with hay and corn silage diets, a second forage is given to the heifers.

For hay-based diets, the 1st and 3rd quartile for the main forage are of 5.8 and 7.6 Kg DM, and they are of 0 and 0.9 Kg DM of concentrates. There is only on group of heifers with hay-based diet that are fed with a second forage, 2.5 Kg DM of straw.

For corn silage as main forage of the diet, the 1st and 3rd quartile for corn silage are of 2.9 and 3.9 Kg DM and they are of 0.2 and 0.7 Kg DM of concentrates. Corn silage-based diet have an important share of a second forage: the 1st and 3rd quartile are of 2.8 and 3.6 Kg DM.

For bailed silage-based diets, the 1st and 3rd quartile are of 6.6 and 7.7 Kg DM for the main forage, and they are of 0.06 and 0.9 Kg DM of concentrates. Two of these diets have a second forage, 0.16 and 0.40 Kg DM of straw.

DETAILED PRESENTATION PER MAIN FORAGE OF THE DIET OF THE GROUP OF HEIFERS OBSERVED

Table 20: Main diets characteristics of heifer groups

DMI	**Minimum, *Kg DM***	**Maximum, *Kg DM***	**1st quartile, *Kg DM***	**3rd quartile, *Kg DM***
Hay	5.6	9.7	6.1	8.6
Bailed silage	6.8	9.4	7.1	8.3
Corn silage	5.2	8.6	6.7	8

Hay

There are 18 hay-based diets, given to heifer group with an average BW between 245 and 455 Kg. These diets allowed during the experiment an ADG of a minimum 310 g/day, maximum 940 g/day. The 1st and 3rd quartile of ADG are of 422 g and 676 g/day. The minimum of DMI for hay-based diet is 5.6 Kg DM (table 23), and the maximum is 9.7 Kg DM. Fifty percent of these group of heifers has their DMI between 6.1 and 8.6 Kg DM.

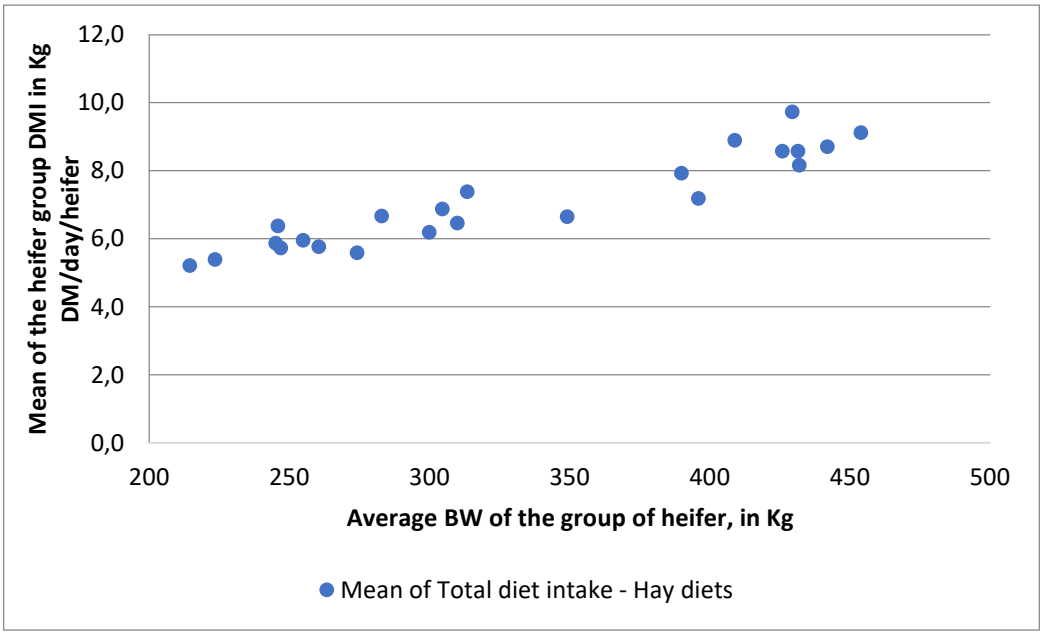


Figure 12: Mean of the heifer group DMI with hay as main forage of the diet

In the figure 12, DMI for heifers around 400 Kg of BW vary with a difference of 0,8 Kg DMI. There are some differences between all heifer groups, but these differences are less important for heifer groups with the same average BW.

Bailed silage

There are 13 bailed-silage diets (12 bailed silage diets and 1 with grass silage), given to heifer group with an average BW between 355 and 450 Kg. These diets allowed during the experiment an ADG of a minimum 268 g/day, maximum 1056 g/day. The 1st and 3rd quartile of ADG are of 607 and 831 g/day. The minimum of DMI for bailed silage-based diet is 6.8 Kg DM (table 23), and the maximum is 9.4 Kg DM. Fifty percent of these group of heifers has their DMI between 7.1 and 8.3 Kg DM.

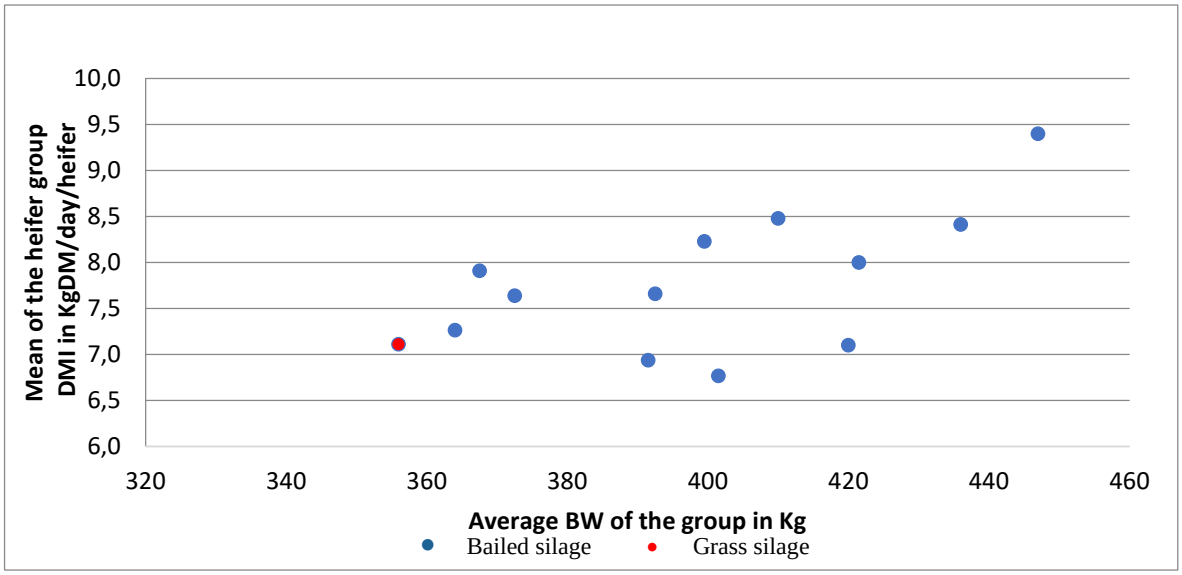


Figure 13: Mean of the heifer group DMI with bailed silage as main forage of the diet

Differences on DMI with bailed silage-based diet for the same average BW is more important than differences on DMI with hay-based diet.

Corn silage

There are 17 diets with corn silage as main diet, given to heifer group with an average BW between 214 and 455 Kg. These diets allowed an ADG of a minimum of 459 g/day and a maximum of 946 g/day. The 1st and 3rd quartile of ADG are of 585 and 813 g/day. The minimum of DMI for corn silage-based diet is 5.2 Kg DM (table 23), and the maximum is 8.6 Kg DM. Fifty percent of these group of heifers has their DMI between 6.7 and 8 Kg DM.

Results indicated that the DMI increased with the increase of heifers BW. Corn silage diets had the lowest heifers DMI compare to hay and bailed silage diets. Heifer groups were fed more with hay as main forage than the other forages.

COMPARISON WITH INRATION

Comparison between real DMI and predicted DMI by INRation v.4, categorized by the main forage

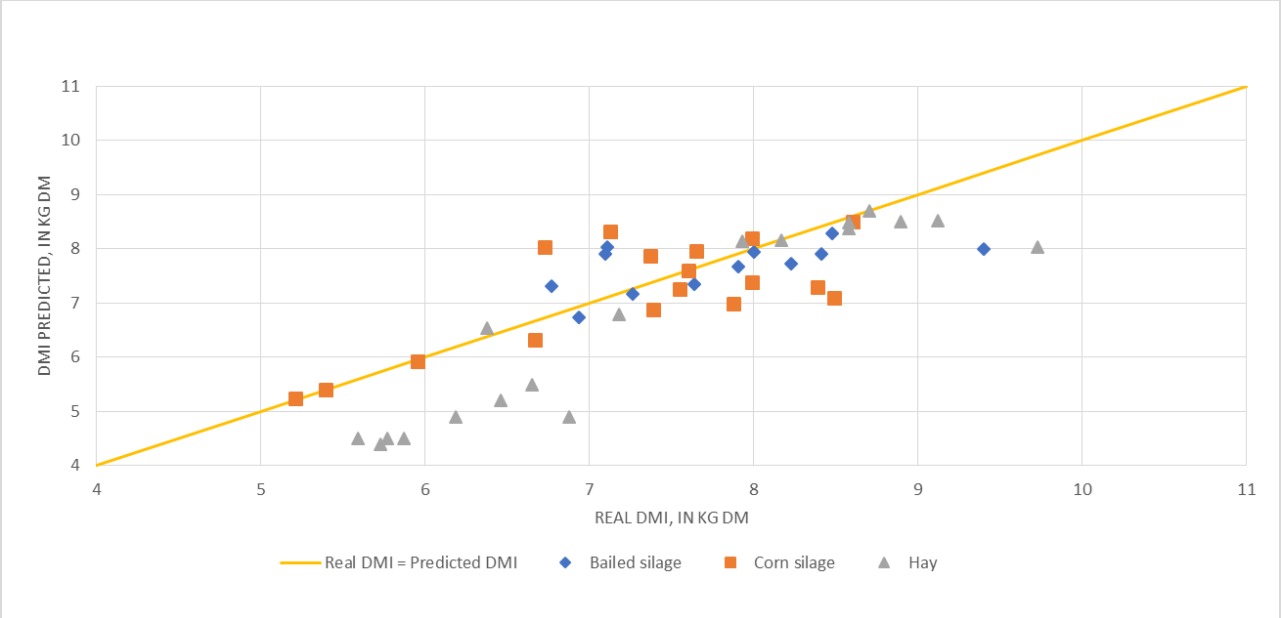


Figure 14: Comparison between real DMI and predicted DMI by INRation v.4, categorized by the main forage

Diets used in these experimental farms and containing hay, haylage and corn silage were integrated in the diet calculation software INRation v.4. For that, all the ingredients of the diet, except the main forage, were determined according to the data given by farms. Heifer BW and age were also set in INRation according to the data given. Almost of hay-based diets data are under the line of equality (figure 14), corn silage-based diet data spread over the line,

above and below, and bailed silage-based diet data are near to the line real DMI equal to predicted DMI.

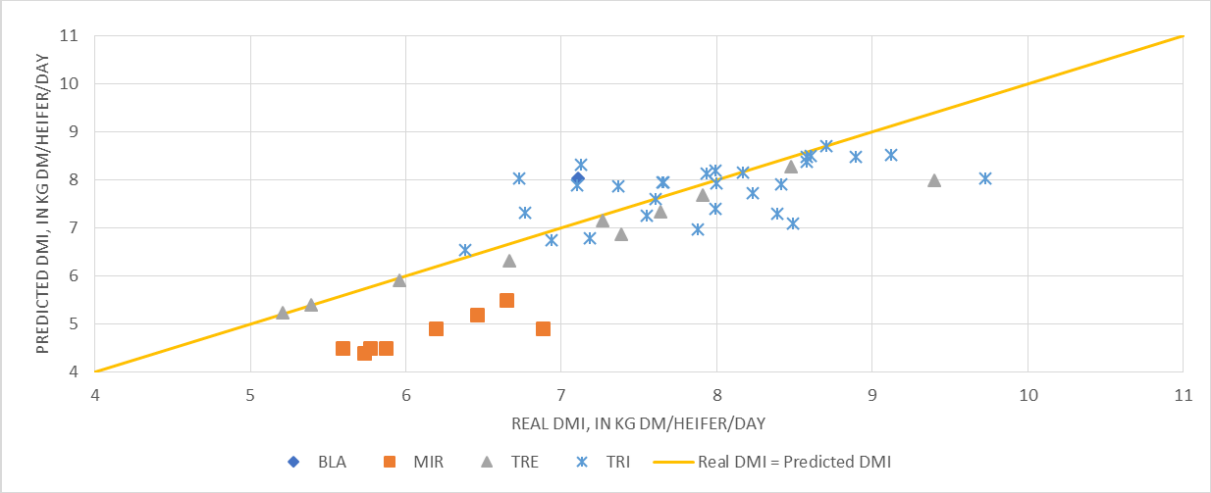


Figure 15: Comparison between real DMI and predicted DMI by INRation, categorized by the farm where data were collected.

In most case, there is no large differences between predicted DMI by INRation and real DMI by heifer in the group. All farms are spread around the equality right (figure 15), except diets from MIR are those are most overestimated by INRation. Diets from TRE are the most accurate.

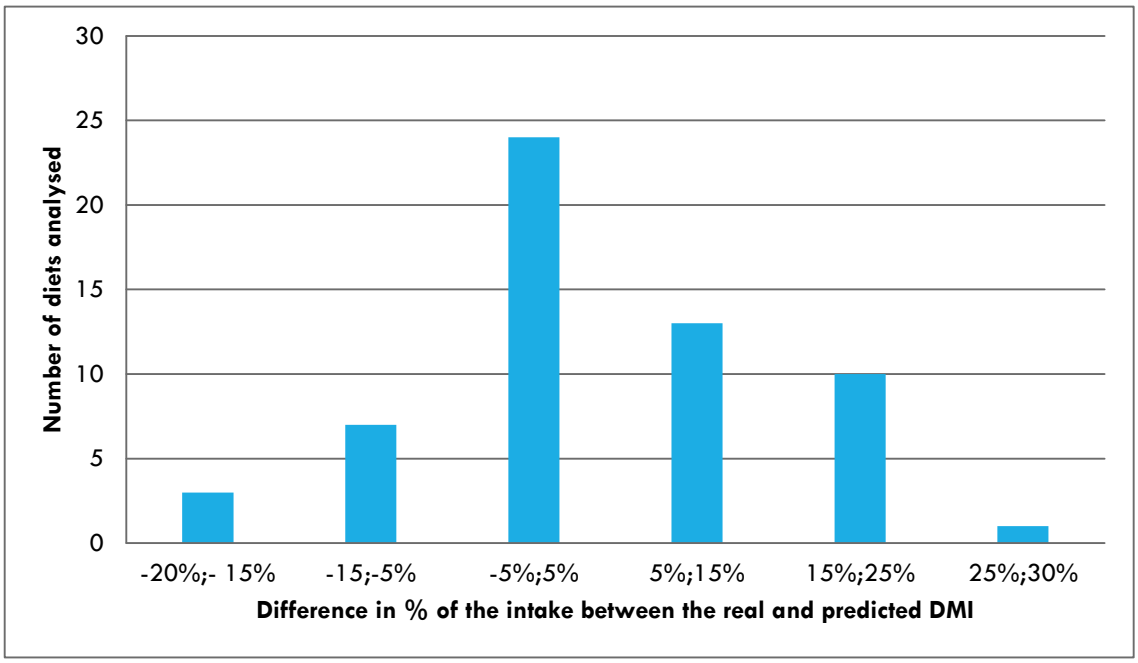


Figure 16: Cumulative frequencies of differences between real DMI and predicted DMI expressed in % of DMI

The calculation used in the figure 16 is: **(Real DMI – Predicted DMI) / Real DMI** expressed in %. The objective was to know what percentage of the predicted DMI is intake by heifers.

INRation software predicted quite well the DMI of the diet given of different heifer group. 75% of these heifer group have a real intake range from -15% and 15% of the predicted DMI by INRation. Overestimation was observed in 11 heifer groups and underestimation in 3 cases

WHAT ARE DIFFERENCES IN DMI ESTIMATES FOR DAIRY HEIFERS ON A WINTER DIET BETWEEN FRANCE AND OTHER COUNTRIES?

The survey for advisors abroad was sent to a dozen people, shared on social networks (Linkedin), however no complete answers was obtained.

Table 21: Dairy heifers DMI according to studies from literature from other countries

Study	**Sample size, number of heifers**	**Average heifers BW, Kg**	**Type of diet**	**Total DMI, Kg DM/day/heifer**

Hoffman. P.C., 2008 *Wisconsin, USA*	6 174 daily DMI measurements	247	Forage and grains	6.5
		300		7.4
		349		8.2
		398		8.7
		449		9.4
		499		10.6
Williams, 2011 *Australia*	297	224	Hay	8.9
	304	210		8.6
Waghorn, 2012 *New Zealand*	164	238	Hay	7.9

Table 22: Comparison between data from French experimental farms and literature from other countries

BW class	Data from French experimental farms, average Kg DM/day/heifer	Data from literature from other countries, average Kg DM/day/heifer		
200-250 Kg	5.7	6.5	8.9 ; 8.6	7.9
250-300 Kg	6	7.4		
350 – 400 Kg	7.6	8.2; 8.7		
400 – 450 Kg	8.2	9.4		
450 – 500 Kg	8.4	10.6		

Only studies with DMI measurements on pure breed dairy heifers, with a BW between 200 and 500 Kg were taking account (table 21). The breed depicted is the Holstein Friesan and the forages given are either hay or ensiling with a supplement to the cereals. In general, the intake

collected on the literature are higher than those measured on French experimental farms (table 22).

DISCUSSION

HOW DO FRENCH DAIRY ADVISORS OPINIONS AND RECOMMENDATIONS ABOUT DAIRY HEIFERS INTAKE ON A WINTER DIET BASED POSITION THEMSELVES IN RELATION TO THE FRENCH FEEDING SYSTEM?

HEIFERS DIETS ACCORDING TO ADVISORS

What emerges from the questionnaire is that the diets made for dairy heifers vary in term of intake and forage used in the diet, which can also be found in the technical documents (Institut de l'Elevage, 2010). The forages cited by the advisors are very diverse, such as hay, grass silage, corn silage and bailed silage. This diversity is reflected in the various technical documents (Institut de l'élevage, 2010 ; Chambre d'agriculture Bretagne, 2008 ; Chambre d'agriculture Meurthe et Moselle, 2014 ; Vergonjeanne, 2015 ; Seuret, 2004). One may also wonder why this diversity, and assume that heifers serve as an adjustment variable in the herd: the feeding of dairy cows with the best forages and heifers with other forages is preferred. However, grass remains the forage of choice, under different forms, because corn silage being an energy-rich forage is first distributed to productive dairy cows.

PERCEPTION AND ESTIMATION OF HEIFERS INTAKE BY ADVISORS

The differences in advisor's estimation of heifer intake were significant, which can be explained on the one hand by the fact that the heifer BW for the same age is not the same chosen by the advisors. Furthermore, rationing is in most cases put in place in order to achieve the objectives set by the farmer, to reduce ADG during winter period in order to favour the compensatory growth of the animal during grassing at spring. So, the heifer intake capacity is not always satisfied because the animals are rationed.

For diets with hay and medium-quality grass silage, there is also great variability in the DMI proposed by the advisors, and that extreme data are really distanced compare to INRA 2018. This variability can be explained by the heifer chosen by the advisor to make this ration, the quality of forage used, and the end goal. Here, a ration of grass and hay is applied, both of medium quality with the main objective of AFC between 28-32 months. However, growth objective was not imposed. Diets are adapted and animals are not fed at will with this main

forage. This is confirmed on the farm by adding to the main diet a coarse forage such as wheat straw to fill the intake capacity of dairy heifers. Farmers prefer a suitable ration in order to achieve their objectives and avoid excessive fattening. This explains why the predictions given by INRation are superior to the data collected from the advisors, since only the main forage was taken into account and ADG predicted are much higher (mostly 900 g/day).

Therefore, the advisors estimate heifer DMI differently. Although they refer to national references, such as INRA (2018), the fact that heifers are characterized approximately on farms, and because of the wide variability in the type of distribution of ration and forage in most cases not analyzed makes the that exact prediction of DMI is difficult.

This mismatch between INRation and the realities of the field is accentuated by the fact that forages for dairy heifers are mostly not analyzed, dairy heifers not weighed, diets given not calculated and given over several days. All these criteria that influence the quality of the ration given and thus influence DMI by the heifer, to which are added the different objectives of the breeder and the passive of the animal (from birth).

DO RECENT INTAKE MEASUREMENTS IN HEIFERS ON A WINTER DIET CORRESPOND TO LITERATURE DATA CURRENTLY USED IN FRENCH FEED FORMULATION SOFTWARE?

APPROACH LIMITS

In the data sample from experimental farms, number of measurements collected is large but not balanced. The higher numbers of data from Trinottières Farm may have influenced the results, but the practice of rearing dairy heifers in Holstein calving 24 months makes it possible to characterize the measurements collected. As for the data from Mirecourt, the low intakes of heifers measured in experiments are due to the fact that this organic farm emphasizes the development of resources with a system with low inputs. Added to this is the fact that all measurements were made on groups of heifers, and that these group are characterized by different numbers of heifers and different length of the trials. Comparison between the rations given on farms and diets integrated into INRation, the forages chosen to make this comparison were based on assumptions about forage energetic values and its fill value. So, these results must be analysed considering these limitations. With individuals intake measurements some of these biases would be avoided. This is what is planned in the suite of the INGELA project.

DIFFERENCES BETWEEN OBSERVED AND PREDICTED INTAKE

The observed differences between predicted and measured intake are for 75% of the data between ±15%, with more than the half with a variation equal or under of ± 5%. This variation is relatively modest as it represents ± 0.4 Kg of forage for a heifer with 400 Kg BW which intake 8 Kg DM/day. These discrepancies can be explained on the one hand by the fact that the forage chosen in INRation is an approximation of the forage actually ingested by the heifer group. In addition, because the animal's weight data is a group average, this also affects the accuracy of heifer ingestion.

CONSEQUENCES OF ERRORS ON ANIMAL WEIGHTS AND FORAGE VALUES

In a case where the same ration is used and intake varied, an observed difference on intake may have greater consequences from a zootechnical point of view. A hay-based diet, with 0.72 UFL as energy value was calculated, with 0.5 Kg of concentrates (wheat) on INRation for different heifer BW. In a second phase, the energy and fill values of forage was increased and decreased on the same time because these two values are linked. DMI was calculated for each situation, as well as the permitted growth (table 21 and table 22).

Table 23: Matrix between heifer BW and hay quality. Output: DMI

Hay – Output of the table: DMI in Kg DM

	Fill Value, UEB	**1.26**	**1.21**	**1.12**	**1.08**	**1.03**
	Energy value, UFL	**0.61**	**0.67**	**0.72**	**0.74**	**0.79**
BW, Kg	*350*	6	6,2	6,7	6,9	7,3
	375	6,4	6,6	7,1	7,3	7,7
	400	6,7	6,9	7,5	7,7	8,1
	425	7	7,3	7,8	8,1	8,5
	450	7,3	7,6	8,2	8,5	8,9
	475	7,7	8	8,6	8,9	9,3
	500	8	8,3	8,9	9,2	9,7

Table 24: Matrix between heifer BW and hay quality. Output: ADG

Hay – Output of the table: ADG in gr/day

	Fill Value, UEB	**1.26**	**1.21**	**1.12**	**1.08**	**1.03**
	Energy value, UFL	**0.61**	**0.67**	**0.72**	**0.74**	**0.79**
BW, Kg	*350 kg*	299	506	720	815	985
	375	298	503	724	819	989
	400	298	506	727	821	987
	425	298	508	728	817	987
	450	293	509	724	817	981
	475	294	503	723	814	976
	500	294	503	719	810	966

If an error on BW of 25 Kg is done with hay with 0.72 UFL, the result is an error in the intake of 0.3 à 0.4 Kg DM, which is still modest since it represents 0.3 and 0.4 * 0.75 / Kg DM which is equivalent to 0.2 à 0.3 UFL/day. Moreover, even if heifers are not weighed on farm, it is difficult to imagine an error of weight estimation more than 75 Kg. To overcome this error on heifer BW, the use of barymetric ribbon with chest measurement benchmark by standard age could eliminate important mistakes on BW estimation (OS Montbéliarde, 2013). On the other hand, for the same weight, an error in the value of the forage leads to significant differences in intake. Especially the growth can vary from single to double with extreme forages and from nearly 300 g/day between forage at 0.67 UFL and 1.21 UEB vs. forage at 0.74 UFL and 1.08 UEB (table 22). And the same goes for other forages such as grass silage.

As heifers are not a lot weighed and forages are poorly analyzed, these variations are likely to exist on farms (Houssin, 2012). As well, because of these errors, economic consequences can exist, if the amount of concentrate and the quality of the forage are not adapted.

Calculation of the DMI is based on the BW of the heifer and the value of the forage and its size. Poor knowledge of the nutritional value of forage and heifer weights has an impact on the intake and growth of the animal. Errors in assessing the weight of the heifer and the value of the forage (energy, FV) are the main issues to be considered so that the feeding system of French heifers INRA predict with a minimal margin of error the intake of dairy heifers.

WHAT ARE DIFFERENCES IN DMI ESTIMATES FOR DAIRY HEIFERS ON A WINTER DIET BETWEEN FRANCE AND OTHER COUNTRIES?

Unfortunately, the questionnaire sent to advisers abroad was found perhaps too long or not clear enough as there was no complete response to return. A follow-up study,

Dairy heifers DMI from other countries are higher than French dairy heifers DMI. Essentially, this could be because of the differences of forage. A study on forage difference would be necessary to determine the share of this factor in the observed DMI difference.

This work shows that errors in estimating the weight of the animal and errors in estimating forage values in particular fill value appear to have more impact than the errors in the intake prediction equations proposed by INRAE. This hypothesis will be verified through the individual intake trial planned at the farm the Pin au Haras in Normandy.

CONCLUSION

This study was based on dairy farmer advisors surveys and analyses of heifers group DMI data from 5 French experimental farms. It shows forages used to feed heifers on farms are diverse, with a predominance for grass-based diets in various forms (hay, bailed silage, grass silage). Advices on heifers feeding and ration calculation are random mainly because of a lack of precision in the parameters (BW, forage values) in order to deliver a more relevant advice.

An analysis of intake data from group heifers on experimental farms suggests that there is low a percentage of error between actual heifer intake and heifer intake predicted by INRation. However, this conclusion must be put into perspective because the calculations parameters are made from averages or estimations: BW used is the average BW of the heifer group, forage values are approximated.

In the light of these results, dairy heifer intake data of the French feeding system INRA 2018 seem correct when the calculation parameters, including the BW of the heifers and the forage values used are precise, but in practice these parameters are poorly measured accurately on the farms.

But French dairy heifers DMI are lower than dairy heifers DMI from other countries, a deeper analysis is needed to understand the real reason of this differences.

This study is extended by trials at the experimental farm in Pin au Haras in Normandie, with individual intake measurements with winter hay and grass-silage diets. These results will enable to confirm or disprove the findings of this work.

BIBLIOGRAPHY

Akdag, A. K. (2018). Voluntary feed intake, grazing behaviour and plant preferences of ruminants. *International Journal of Scientific and Technilogical Research, Volume 4*(N°9), 12p.

Allen, S. M. (2014). Drives and limits to feed intake in ruminants. *Animal Production Science, Volume 54*, 1513-1524.

Álvarez, C. W. (2019). A method for measuring energy content in compound feeds in the NorFor system. *Proceedings of the 10th Nordic Feed Science Conference.* Uppsala, Sweden.

Ball, D. C. (2001). *Understanding forage quality.* Park Ridge: American Farm Bureau Federation Publication 1-01.

Berry, D. C. (2014). International genetic evaluations for feed intake in dairy cattle through the collation of data from multiple sources. *Journal of Dairy Science 97, Volume 97, Issue 6*, 3894-3905.

Betchel, W. (2018, October 8). *Feeding space for heifers.* Récupéré sur Dairy Herd Management: https://www.dairyherd.com/news-news/feeding-space-heifers

Chambre d'agriculture Bretagne. (2008). *Alimentation minérale des génisses laitières: Optimiser l'apport de minéraux.*

Chambre d'agriculture Meurthe et Moselle. (2014). *Cas type bovins lait - Itinéraire Génisse Prim'Holstein.* Chambre d'agriculture Meurthe et Moselle. Consulté le September 23, 2020, sur https://meurthe-et-moselle.chambre-agriculture.fr/fileadmin/user_upload/Grand-Est/036_Inst-Meurthe-et-Moselle/RUBR_Productions_agricoles/Productions_animales/Cas_types_bovin_lait/iti_genisses_PH.pdf

Chambre d'agriculture Nord-Pas de Calais, G. d.-S.-O. (2010). De l'herbe récoltée pour alimenter les génisses. Dans Collectif "Tous autour de l'herbe", *Fiches techniques "Tous autour de l'herbe"* (Vol. Fiche 36, p. 2p).

Chambre de l'agriculture des Pays de la Loire, I. d. (2018). Repères techniques et économiques en élevage laitier. *Collection références*, 6p. (Institut de l'Elevage, Éd.) Consulté le September 22, 2020, sur https://pays-de-la-loire.chambres-agriculture.fr/fileadmin/user_upload/National/FAL_commun/publications/Pays_de_la_Loire/2018_Reperes_techniques_economiques_elevage_laitier_resultats_2016_projections_2017.pdf

Chambres d'Agriculture de Bretagne. (2017). Génisses laitières, moins de tracas, plus de résultats. *Rendez-vous techniques Bovins* (p. 7p). Chambres d'agriculture de Bretagne.

CVB. (2008). *Tabellenboek Veevoeding.* Wageningen: Federatie Nederlandse Diervoederketen.

CVB. (2016). *Table Booklet Feeding of Ruminants* (Vol. In Dutch "Tabellenboek Veevoeding"). Wageningen: Federatie Nederlandse Diervoederketen.

Faverdin, P. B. (1995). Control and prediction of feed intake in ruminants. *Recent developments in the nutrition of herbivores. Proceedings of the 4. international symposium on the nutrition of herbivores.* (pp. 95-120). Clermont-Ferrand (France): INRA Editions.

Greter, A. D. (2008). Nutrient intake and feeding behavior of growing dairy heifers: Effects of dietary dilution. *Journal of Dairy Science, Volume 91, Issue 7*, 2786-2795.

Heinrichs, A. Z. (2017). A 100-year Review : A century of dairy heifer research. *Journal of Dairy Science Vol. 100 No. 12*, 16.

Henry, W. M. (1915). *Feeds and Feeding: A Handbook for the Student and Stockman (15th ed.).* Madison: Morrison Publishing Company.

Hoffman, P. S. (2001). Understanding NDF digestibility of forages. *Focus on forage - Wisconsin team forage, Volume 3*(N°10), 3p.

Houssin. B., H. A. (2012). *Le tour de poitrine, un outil de mesure du développement des génisses Normandes.*

Huhtanen, P. R. (2008). Evaluation of concentrate factors affecting silage intake of dairy cows: A development of the relative total diet intake index. *Animal : an international journal of animal bioscience, Volume 2, Issue 6, ,* 942-953.

Huyghe, C. (2009). Evolution des prairies et cultures fourragères et de leurs modalités culturales et d'utilisation en France au cours des cinquantes dernières années. *Fourrage*, 407-428.

IDELE. (2018). *Adapter la période de vêlage à la ressoucre en herbe.*

INRA. (1978). *Alimentation des ruminants. : principes de la nutrition et de l'alimentation des ruminants, besoins alimentaires des animaux, valeur nutritive des aliments.* INRA Publications.

INRA. (2018). *Alimentation des ruminants* . Versailles, France: Editions Quae.

Institut de l'élevage. (2010). De la digestion des aliments au calcul des besoins des animaux : les bases de l'alimentation des bovins . *Guide Pratique de l'alimentation du troupeau bovin laitier* , 13-28.

Institut de l'Elevage. (2010). *Guide pratique de l'alimentation du troupeau bovin laitier.* Editions Quae.

Institut de l'Elevage. (2014). *Les jeunes femelles d'élevage : un capital à faire fructifier.* Consulté le October 6, 2020, sur idele.fr: http://idele.fr/no_cache/recherche/publication/idelesolr/recommends/les-jeunes-femelles-delevage-un-capital-a-faire-fructifier.html

Institut de l'Elevage, C. d. (2017). *Utiliser des aliments fermiers pour élever les génisses.* Récupéré sur http://idele.fr/services/outils/autosysel/stockage-fiches/bl/utiliser-des-aliments-fermiers-pour-elever-les-genisses.html

Institut de l'Elevage, C. d. (2020). *Que peut-on attendre de la croissance compensatrice en élevage laitier?* GEREL: L'élevage des génisses laitières.

Khan, M. B. (2016). Invited review: Transitioning from milk to solid feed in dairy heifers. *Journal of Dairy Science, Volume 99, Issue 2*, 885-902.

Krizsan, S. H. (2014). *Evaluation of the feed intake models in the Nordic feed evaluation system NorFor* .

Le Cozler, Y. (2015). Reproduction chez la génisse laitière. *Repromag*, 12-23.

NRC. (1996). *Nutrient Requirements of Beef Cattle, 7th Ed.* . Washington DC: National Academies Press.

NRC. (2001). *Nutrient Requirement of Dairy Cattle: Seventh Revised Edition.* Washington DC: The National Academies Press.

NRC, S. o. (1981). *Effect of Environment on Nutrient Requirements of Domestic Animals.* Washington, D.C.: National Academies Press (US).

OS Montbéliarde, I. d. (2013). *Génisses, mesurer le tour de poitrine.*

Quigley, J. J. (1986). Dry Matter Intake in Dairy Heifers. 1. Factors Affecting Intake of Heifers under Intensive Management. *Journal of Dairy Science, Volume 69*, 2855-2862.

Scohy, D. (2020, April 20). *Quelle ration pour les génisses laitières?* Consulté le September 18, 2020, sur Web-Agri: http://www.web-agri.fr/conduite-elevage/alimentation/article/ration-pour-les-genisses-laitieres-foin-enrubannage-ensilage-ration-seche-1172-167373.html

Seuret, J. J. (2004). *Guide Optimiser l'alimentation et la conduite, Chambres d'agriculture de Bretagne.* Chambres d'agriculture de Bretagne.

Sundstol, F. (1993). Energy sytems for ruminants. *Iceland Agriculture Science, Volume 7*, 11-19.

Van Soest, P. J. (1967). Development of a comprehensive system of feed analyses and its application to forages. *Journal of Animal Science, Volume 26, Issue 1*, Pages 119-128.

Vergonjeanne, R. (2015, April 30). *Alimentation des génisses laitières Foin, enrubannage, ensilage ou paille : Quelle ration choisir?* Consulté le October 6, 2020, sur Web-Agri: http://www.web-agri.fr/conduite-elevage/alimentation/article/foin-enrubannage-ensilage-ou-paille-quelle-ration-choisir-1172-109645.html

Volden, H. N. (2011). Prediction of voluntary feed intake. *NorFor - The Nordic Feed Evaluation System* , 141-165.

Waghorn, G. M. (2012). *Measuring residual feed intake in dairy heifers fed an alfalfa (Medicago sativa) cube diet.*

Williams, Y. P. (2011). *Variation in residual feed intake in Holstein-Friesian dairy heifers in southern Australia.*

APPENDIX 1

SURVEY AIMED TO FRENCH DAIRY ADVISORS (2 PAGES)

Alimentation hivernale des génisses laitières âgées de 6 mois à 18 mois

Ce questionnaire est proposé dans le cadre du projet INGELA (INGestion des GEnisses LAitières). Les données récoltées permettront d'établir un état des lieux des pratiques rencontrées sur le terrain en matière d'alimentation hivernale des génisses laitières âgées de 6 à 18 mois.

Durée: 20 minutes environ

Bon questionnaire !

Il y a 25 questions dans ce questionnaire.

Identité

1 Quel est votre profession? *

Veuillez sélectionner une réponse ci-dessous

Veuillez sélectionner une seule des propositions suivantes :

- Conseiller
- Vétérinaire
- Encadrant/Responsable technique
- Autre

2 Pour quel organisme/entreprise travaillez-vous? *

Veuillez écrire votre réponse ici :

3

Email

Si vous souhaitez avoir un retour sur les résultats de l'enquête

Veuillez écrire votre réponse ici :

Profil général

Pour valider les questions à choix multiple, chaque proposition de réponse doit avoir une réponse. Mettez 0% pour une proposition de réponse nulle.

Merci de faire attention à la logique de vos réponses, afin de faciliter le traitement des données :

- +75% : Une seule réponse possible
- 51-75% : Une seule réponse possible
- de 0% à 50% : Au choix

4 Quel est votre secteur géographique de travail? *

Veuillez écrire votre réponse ici :

5 Combien suivez-vous d'élevage? *

Seuls des nombres peuvent être entrés dans ce champ.

Veuillez écrire votre réponse ici :

6 Quelle est la typologie des exploitations que vous conseillez? *

Choisissez la réponse appropriée pour chaque élément :

	0%	-25%	26-50%	51-75%	+75%
o Bovins lait Plaine spécialisés					
o Bovins lait Plaine Mixte Lait-viande					
o Bovins lait + Polyculture					
o Bovins lait Montagne spécialisé					

Pour valider la question, chaque proposition de réponse doit avoir une réponse. Mettez 0% pour les propositions de réponses nulles.

Merci de faire attention à la logique de vos réponses, afin de faciliter le traitement des données :

- +75% : Une seule réponse possible
- 51-75% : Une seule réponse possible
- de 0% à 50% : Au choix

7 Quelles sont les races de génisses laitières les plus rencontrées dans vos élevages? *

Choisissez la réponse appropriée pour chaque élément :

	0%	-25%	26-50%	51-75%	+75%
Prim'Holstein					
Normande					
Montbéliarde					
Autre					

Pour valider la question, chaque proposition de réponse doit avoir une réponse. Mettez 0% pour les propositions de réponses nulles.

Merci de faire attention à la logique de vos réponses, afin de faciliter le traitement des données :

- +75% : Une seule réponse possible
- 51-75% : Une seule réponse possible
- de 0% à 50% : Au choix

8 Quelle est la répartition des élevages en fonction de l'âge au premier vêlage? *

Choisissez la réponse appropriée pour chaque élément :

	0%	-25%	26-50%	51-75%	+75%
24 - 28 mois					

	0%	-25%	26-50%	51-75%	+75%
28 - 32 mois					
+32 mois					

Pour valider la question, chaque proposition de réponse doit avoir une réponse. Mettez 0% pour les propositions de réponses nulles.

Merci de faire attention à la logique de vos réponses, afin de faciliter le traitement des données :

- +75% : Une seule réponse possible
- 51-75% : Une seule réponse possible
- de 0% à 50% : Au choix

Pratiques d'alimentation sur le terrain

Alimentation hivernales pour les génisses laitières âgées de 6 à 18 mois

9

Quelles sont les rations hivernales des génisses laitières utilisées par les éleveurs de votre secteur d'activité?

Indiquez la part du fourrage principal utilisée pour les 2

10 Dans combien d'élevages faites-vous du conseil sur les génisses? *

Seuls des nombres peuvent être entrés dans ce champ.

Veuillez écrire votre réponse ici :

11 Dans combien d'élevages calculez-vous des rations pour génisses laitières? *

Seuls des nombres peuvent être entrés dans ce champ.

Veuillez écrire votre réponse ici :

12 Quel logiciel de rationnement utilisez-vous? *

Veuillez sélectionner une réponse ci-dessous

Veuillez sélectionner une seule des propositions suivantes :

- INRation ou un logiciel basé sur le système INRA
- Je n'utilise pas de logiciel pour calculer mes rations
- Autre

13 Quel(s) autre(s) moyen(s) utilisez-vous pour conseiller des rations hivernales pour les génisses laitières? Pourquoi? *

Répondre à cette question seulement si les conditions suivantes sont réunies :

La réponse était 'Je n'utilise pas de logiciel pour calculer mes rations' à la question '12 [C4]'

De quelle manière avez-vous répondu à la question précédente?

Question précédente : Sur quelle quantité totale de MS vous basez-vous pour prédire le calcul de vos rations?

*

Veuillez sélectionner une réponse ci-dessous

Veuillez sélectionner une seule des propositions suivantes :

- Au feeling (vous avez l'habitude de manipuler ces données)
- En utilisant un rationneur

Rations hivernales types pour génisses laitières

Pour les 2 prochaines questions il vous sera demander de renseigner des rations hivernales pour 2 fourrages (foin et ensilage d'herbe) pour 3 différentes catégories d'âge de génisses laitières.

Veuillez s'il vous plaît bien renseigner les champs afin que l'analyse des résultats puisse être réalisée dans des conditions optimales.

Merci à vous.

20

Pouvez-vous nous décrire des RATIONS HIVERNALES types que vous conseillez :

- **Pour des génisses laitières de grands format (Prim'Holstein, Montbéliarde, Normande)**
- **Pour un objectif de vêlage entre 28 et 30 mois**
- **Avec pour fourrage principale un foin de graminé de qualité moyenne**
- ***Renseignez toutes les cases, si vous devez laissez des cases vides, mettez un point.***
- ***Donnez des quantités en kgMS/jour/génisse pour le fourrage et en kgBRUT/jour/génisse pour les autres aliments***

*

	A partir de 6 mois	12 mois	18 mois
Foin graminé de qualité moyenne			
Aliment concentré 1			
Aliment concentré 2			
Aliment minéral (CMV)			
TOTAL kgMS/jour/génisse			

21

Décrivez le type et/ou la composition du/des concentré(s) utilisé(s) dans votre ration à la question précédente. Faites de même avec le minéral.

*

Veuillez écrire votre réponse ici :

22

Pouvez-vous nous décrire des RATIONS HIVERNALES types que vous conseillez :

- **Pour des génisses laitières de grands format (Prim'Holstein, Montbéliarde, Normande)**
- **Pour un objectif de vêlage entre 28 et 30 mois**
- **Avec pour fourrage principale un ensilage d'herbe graminé, préfané de qualité moyenne**
- ***Renseignez toutes les cases, si vous devez laissez des cases vides, mettez un point.***
- ***Donnez des quantités en kgMS/jour/génisse pour le fourrage et en kgBRUT/jour/génisse pour les autres aliments***

*

	6 mois	12 mois	18 mois
Ensilage d'herbe graminé, préfané de qualité moyenne			
Aliment concentré 1			
Aliment concentré 2			
Aliment minéral (CMV)			
TOTAL kgMS/jour/génisse			

23

Décrivez le type et/ou la composition du/des concentré(s) utilisé(s) dans votre ration à la question précédente. Faites de même avec le minéral.

*

Veuillez écrire votre réponse ici :

Point de vue personnel

Cette partie ouverte du questionnaire est dédiée à vos remarques personnelles.

24 Quelles sont vos attentes pour mieux conseiller les éleveurs pour l'alimentation hivernale des génisses?

Veuillez écrire votre réponse ici :

25 Remarque(s) à propos de la capacité d'ingestion des génisses laitières en général

Veuillez écrire votre réponse ici :

Ecriture libre

Merci de votre participation ! Les résultats seront disponible à la fin du projet

Envoyer votre questionnaire.
Merci d'avoir complété ce questionnaire.

APPENDIX 2

SURVEY AIMED TO ADVISORS FROM OTHER COUNTRIES (2 PAGES)

Intake capacity of dairy heifers between 6 and 18 months: How much dry matter can they eat?

Currently as an intern on the French Livestock Institute (IDELE), and as part of my European Engineer thesis in livestock production, I am trying to determine whether the ingestion capacity of dairy heifers aged 6 to 18 months has changed.

This thesis is part of a French project, INGELA that aims to update the data about intake capacity of the dairy heifers. Indeed, since 1988, the Agricultural French Research Institute INRAE (Institut National de recherche pour l'Agriculture et l'Environnement) still has the same dairy heifers intake capacity benchmarks. Yet the dairy heifer and the farming methods have changed a lot. So, what about the intake capacity?

As well as carry out in France an inventory of dairy heifers intake in farms and a data collection about individual intake on experimental farm, I propose you this survey to report on the situation abroad.

Thank you in advance for your replies!

Time : around 20 minutes

Enjoy the survey!

Link to the French Livestock Institute website: http://idele.fr/linstitut-de-lelevage/in-english/who-we-are.html

There are 18 questions in this survey.

General profile

Aim:

Specify target group

What is your job ? *

Please choose **only one** of the following:

- Advisor
- Independant consultant
- Instructor / Trainer
- Veterinarian
- Other

In which company do you work? *

Please write your answer here:

In which geographic area do you work?

Please specify the country and the region.

*

Please write your answer here:

Are you a dairy heifers specialist? *

Please choose **only one** of the following:

Estimation of dairy heifers Dry Matter Intake (DMI)

Aim:

Learning about thoughts/opinions and benchmarks about the reliability of DMI estimation in dairy heifers as currently use in practice.

What are the heifers breed the most encountered in your area?

Name 2 main breed, with proportions if it is possible

*

Please write your answer here:

What is the average first age at calving of the dairy heifers in your area? *

Please choose **only one** of the following:

- Early (Between 24-28 months)
- Middle late (Between 28-32 months)
- Late (More than 32 months
- Other

Mainly, what kind of forage is given to the dairy heifers during winter feeding by farmers in your area?

Please indicate the prevalence of the forage for two heifers categories. The total must be 100%.

*

Please choose the appropriate response for each item:

	Dairy heifers 6-12 months	Dairy heifers 12-18 months

	0	-25%	26-50%	51-75%	+75%	0	-25%	26-50%	51-75%	+75%
Corn silage										
Grass silage										
Hay										
Straw										
Remains of the dairy cows diet										

Which software do you use? With which feed system (INRA, NRC, NorFor, CVB..)? *

Please write your answer here:

So, how do you do to calculate a ration for dairy heifers? Please indicate which feed system do you use (INRA, NRC, CVB, NorFor..)

*

We know that the intake is mainly influenced by both heifer intake capacity and forage fill value. The objectives of these 2 following questions is to know, the ration type that you could advice on farms with not analysed forage.

Can you describe a winter type of feed ration that you could advise :

- **For dairy heifers**
- **Precise if it is a small or large dairy breed**
- **For an age at first calving between 28-30 months**
- **Main forage: medium quality hay**
- ***Give quantities in kgDM/day/heifer for forage, and kg/day/heifer for concentrates.***
- ***If in one case you have no response, put a dot to validate the question***

*

	Heifers more than 6 months	Heifers 12 months	Heifers 18 months
Large or small			

the question

*

	Heifers after 6 months	Heifers 12 months	Heifers 18 months
Small or large breed?			
Medium quality grass silage			
Concentrate number 1			
Concentrate number 2			
Mineral			

Free writing: Thoughts about rearing dairy heifers in its globality or about dairy heifers intake capacity more precisely.

Please write your answer here:

Are you willing to be interviewed by me? *

Please choose **only one** of the following:

Please, give me your email telling if you want that I will send by email you several more questions (4-5) or if you want to make a phone appointment.

*

Please write your answer here:

Thank you a lot for answering this survey! Don't hesitate to contact me for further informations.

Danièle Tremblais

European Engineer Degree in Livestock Production in AERES in Dronten (The Netherlands)

Intern in French Livestock Institute (IDELE)

Contact: daniele.tremblais@idele.fr

Submit your survey.
Thank you for completing this survey.