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Assessment of feeding management, characteristics of rations and the nutritional status of dairy cows in Styrian farms

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1. Introduction and Hypotheses

In the past, milk production was mostly based on small rural farms in Austria. Austrian typical hilly and mountainous areas are destined for animal production because of the optimal use of steep fields and alpine meadows through the grazing by mostly ruminants. This applies precisely to the Styrian landscape. Additionally, diverse kinds of agroecosystems in Styria require different strategies of agricultural feed production and therefore result in different feed sources in ruminant adequate diets.

Due to farm specialization (Poppe et al. 2007) and for the above reasons, the origin of feed had become diverse and with it the feed quality. Farms mostly produced their forage feed on their own and purchased the concentrates from national and international production facilities. Climate change and the associated extreme weather conditions also affected the quantity of feed. In the south-east region of Austria like Styria, the precipitation decreased and dryness periods were enlarging over the years (Janke et al. 2015). Little quantity of forage feed sources led to an increasing part of feed with bad nutritional quality and poor safety resulting in insufficient supply and further consequence in milk yield depression and metabolic diseases. However, good feed quality is essential to satisfy the high nutrient requirements related to the high milk yield that is economically expected. Although farmers tried to keep feed costs low, for example by producing as much feed as possible on their own farm, feeding comprised > 50 % of the total costs of dairy production (Haas et al. 2014).

Despite the complexity of the above-mentioned factors, adequate rations for ruminants were composed nowadays in Austria. The farmers and their production systems were challenged by the high nutritive requirements associated with high productive performance while still maintaining the health and welfare of animals. Indeed, animal health supports the productivity and expected longevity of the animals, making that animal health even became a breeding goal in Austria (Kalcher et al. 2020). Feedstuff selection, farm management factors and environmental factors during plant growth on the fields combined with feed processing and storage at the farms play an essential role in feed quality that directly affect the nutritional status and therefore the health and welfare of animals. Lower amounts of nutrients as well as contaminated feed are the result of disbalances of these factors.

In general, data for on-farm impacts on feed quality, nutrition and hygiene on production and health of dairy cows are rare. This thesis aimed to assess whether production and metabolic problems are developing due to deficient feed quality and hygiene in Styrian dairy farms.

Styrian dairy production was of interest because it consists of relatively smaller size farms in hilly and mountainous areas and therefore tends to show substantial diversity regarding the composition of feeds, and feeding and farm management.

Following hypotheses were developed about Styrian dairy farms:

1. Styrian dairy farms use a variety of feed composition and feeding management which results in the different nutritional and hygienic quality of feeds among the farms.
2. Farms with good quality feed and well managed in terms of nutrition and hygiene of feeds will have reduced incidence of metabolic health problems and thereby better productivity.

2. Review

2.1. Dairy production in Austria and Styria

Milk production was the second biggest agricultural sector in the EU in terms of the output value coming after the vegetable and horticultural plant sector. 97 % of the milk output was produced by cows. The remaining part of 3 % was produced by goats, sheep and other species (M.-L. Augère-Granier December 2018). According to Eurostat 2020 (annex 1), an increase in cow milk production of 0.0 % up to over 7.5 % (definition in the legend of annex 1) was recorded from 2015 to 2018 across all politically defined Austrian regions, which emphasized the importance of milk production in Austria. The European interest of this period was caused by the abolishment of the milk quota in 2015 (Eurostat 2020).

In Austria, the Federal Recording Organization (in German: Landeskontrollverband Austria Gemeinnützige GmbH) (LKV) provided a reliable milk production database. The provided data were updated annually. The annual report 2019 was the current one. Over the last decades, the database volume increased by taking more and more lactating cows under the control of milk performance testing. The number of lactating cows with continuous milk performance testing data increased over the past 15 years from 49.2 % in 1995 to 82.1 % in 2019. This proportion was almost doubled until nowadays (Kalcher et al. 2020). The average milk yield per cow per year had constantly been increasing from 1999 to 2019. This fact was shown in all main dairy breeds. In absolute values, an increase of 1,928 kg milk per cow per year was recorded in the Holstein Frisian (HF) breed, 2,191 kg in the Simmental (FV) breed and 1,551 kg in the Brown Swiss (BS) breed within the last 20 years. In 2019, the average milk yield per cow per year was 8,972 kg milk in the HF breed, 7,734 kg milk in FV and 7,527 kg milk in BS. Across all main dairy breeds, the life performance of milk production showed a steadily rising curve during this period resulting in 30,313 kg milk per cow in 2019 (Kalcher et al. 2020).

Austria was undergoing a structural change in terms of farm sizes and the number of farms. Currently, dairy farms with more than 50 lactating cows per year were distributed all over Austria (Fig. 1). On the map, a high density of farms of this size is visible in Upper Austria. Still, in 2020, the average dairy herd size was only 22.8 cows per farm in Austria. So, it is to assume that quite a big number of small farms coexisted with very big farms in Austria. Small farms were more common in mountainous areas. Nevertheless, the trend of a steady increase of herd sizes and a decrease in the number of farms was recorded as well as a slight increase in the average milk yield in Austria. The milk yield over all measured lactations and breeds was 7,896 kg milk annually with 4.14 % fat and 3.43 % protein (LKV Austria 2021b). The milk yield report of 2020 was proof of a constant increase this productive aspect. Improved fitness parameters and animal health played a big role in this context (LKV Steiermark 2020b). Other parameters like genetics and good quality forage also contributed to the economic growth (LKV Steiermark 2020a).

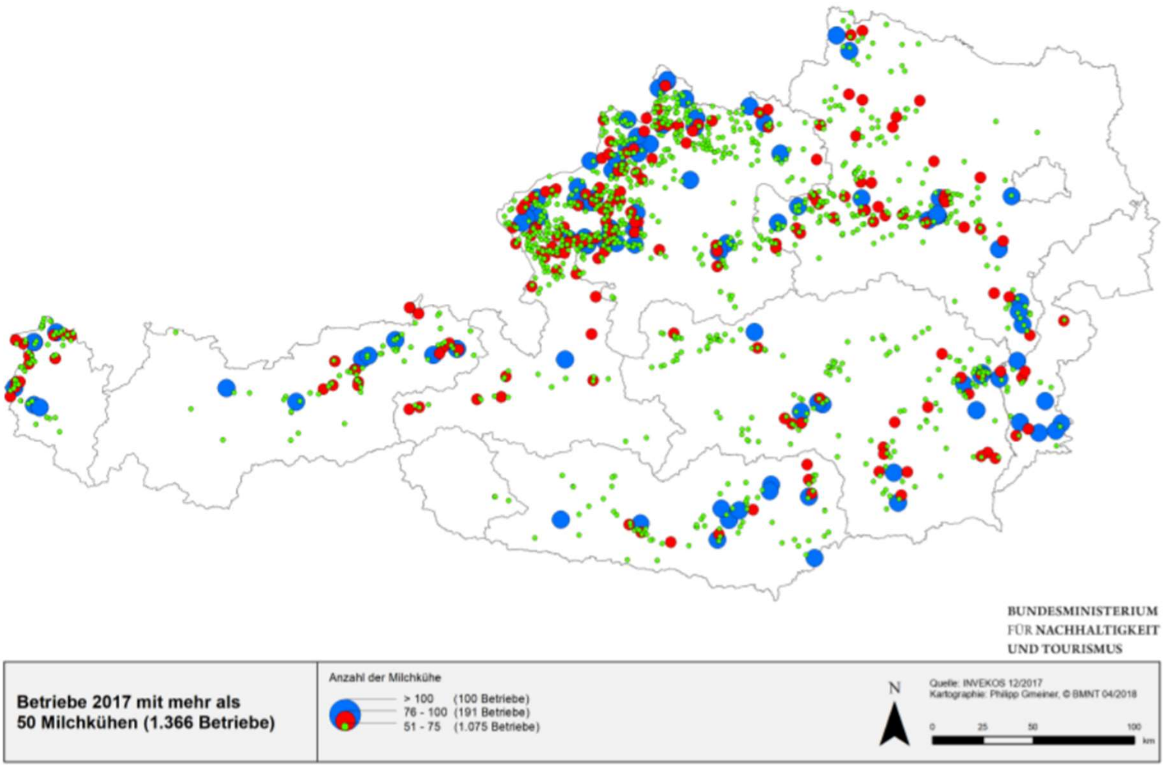

Fig. 1 Distribution of farms with more than 50 dairy cows in Austria in 2017 (original source: INVEKOS 12/2017; cited from Wöckinger 2018); INVEKOS = integrated administration and controlling system (BMLRT 2021), N = north.

Among the Austrian provinces, Upper Austria (588 farms) and Lower Austria (288 farms) dominated the dairy sector (Fig. 2). However, Burgenland had the largest number of lactating cows per farm, but only a small number of farms (LKV Steiermark 2020b). Figure 2 showed the trend of an east-west gradation having large farms in eastern Austria and more small farms in western Austria. Styria, in particular, was ranked quite in the middle. Compared to other provinces, it had large farms as well as small farms. According to the LKV annual report 2019, Styria was ranked thirdly with 205 dairy farms with more than 50 lactating cows per year and on average, Styrian farms kept about 24.3 registered cows per registered farm (Kalcher et al. 2020). Because of different lactating herd sizes, milk yield per farm also differed among Austrian provinces. Higher average herd sizes had higher performance data. The Styrian average milk yield was 7,939 kg milk with 4.14 % fat and 3.45 % protein (LKV Steiermark 2020a).

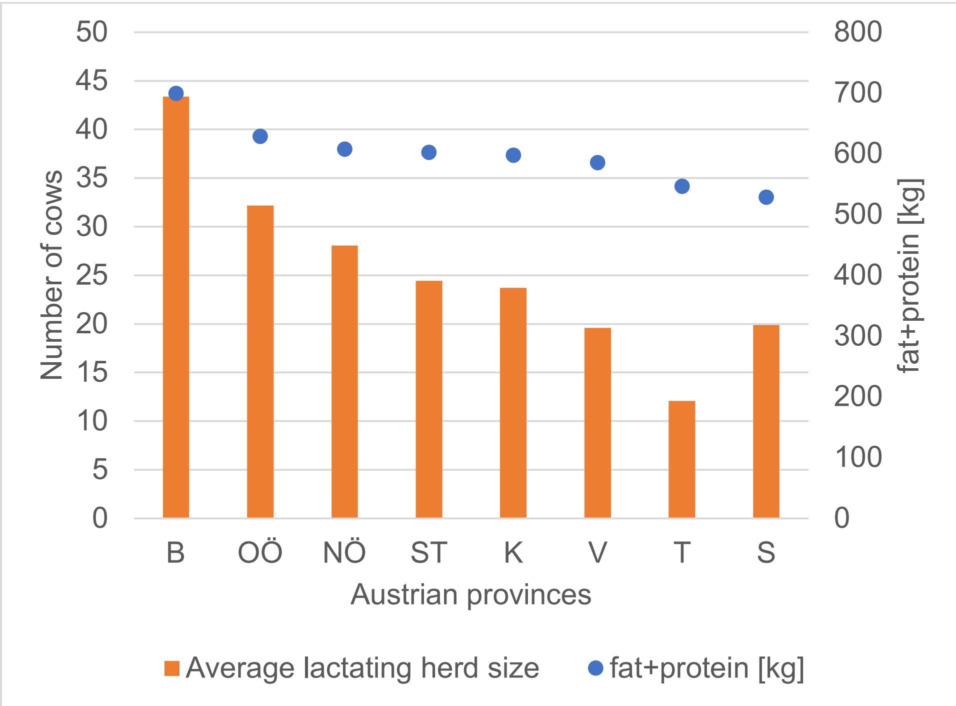

Fig. 2 Average lactating herd sizes and their performance (fat+protein [kg]) per lactation in different Austrian provinces (LKV Steiermark 2020a); B = Burgenland, OÖ = Upper Austria, NÖ = Lower Austria, ST = Styria, K = Carinthia, V = Vorarlberg, T = the Tyrol, S = Salzburg.

Although the farm size and milk yield in Styria tended to be smaller than in Upper Austria and Lower Austria, like other Austrian provinces, structural changes were noted in Styria as shown in table 1. In Styria, 2,698 dairy farms were recorded during the milk testing period in 2020. This number signified a loss of 82 Styrian farms (-2.9 %) in comparison to recorded numbers in the milk yield report the year before. Another sign of current structure change was given by the increase of the average number of cows per farm that were included in the milk performance testing up to 24.4 cows per farm (+0.5 %) in 2020 (number of 2019). The same year’s total number of 65,903 (-470) recorded dairy cows decreased in comparison to that. It corresponded to the percentage of Styrian dairy cows included in the testing system of LKV of

82.4% lactating cows. Additionally, a slight increase was noted in milk yield as well as in milk constituents. This trend is visualized in annex 2 when split by breed. All breeds had a positive trend, even though the HF cows had a constant higher milk yield than BS and FV, which showed a quite similar curve (LKV Austria 2020, LKV Steiermark 2020a).

Tab. 1 General overview of milk yield in the “Milchleistungsbericht 2020” (LKV Steiermark 2020c).

	Farms	Cows with testing results	Standard lactations	Milk kg	Fat %	Protein %	Fat+protein kg
2020	2,698	65,903	56,825	7,939	4.14	3,45	603
Differences to the previous year	-82	-470	-402	+221	+0.02	+0.03	+16

Except for notifiable animal diseases surveilled by governmental animal health programs (Wagner 2021) there was no official regular animal health data available about dairy farms for the whole of Austria or by provinces like Styria for example, although a monitoring of animal health parameters had been implemented through the milk performance testing by LKV since 2006. This monitoring procedure was part of an Austria-wide project initiated by the Association of Austrian Cattle Breeders (in German: Zentrale Arbeitsgemeinschaft österreichischer Rinderzüchter) (ZAR) to provide useful information to improve herd management, veterinary support and breeding. According to ZAR, including animal health parameters into breeding goals will have economic advantages in terms of costs for veterinary services and following costs out of it like lower milk yield or shorter durability of the affected cow due to illnesses (Egger-Danner et al. 2010). The mentioned breeding goals of ZAR were based on a Scandinavian role model. These countries already implemented animal health detection systems with success (Østerås and Sølverød 2005). Furthermore, Swedish researchers concluded no inevitable association between increased milk production and higher incidences of so-called production diseases like ketosis, mastitis and lameness. However, upcoming selection strategies to breed for higher milk yielding cows would be unwise when ignoring health consequences coming along (Ingvartsen et al. 2003). Nevertheless, Austrian farm individual prevalence data of diseases typically occurring in dairy cows were available – named LKV “daily” report. They could at least show farm individual animal health data over the period of three months and give an idea what the average herd prevalence of certain disease could be in Styrian farms. Regarding lameness, several Austrian studies provided prevalence data. A mean lameness herd prevalence of 31 % (range 6-70 %) was the result from 30 dairy farms in Upper Austria, Lower Austria and Styria, surveyed during the winter housing period of 2004/2005 (Dippel et al. 2009). Another study recorded a median lameness herd prevalence of 36 % (range 0-77 %) in 80 herds with 21 to 55 cows per farm in Upper and Lower Austria. 4 % of the assessed cows per herd showed severe lameness (Rouha-Mülleder et al. 2009). A third Austrian study investigated new therapy strategies for “non-healing” claw defects caused by bovine dermatitis digitalis (BDD). This study used cases with BDD-associated lesions from three dairy farms in Lower Austria and Styria with a mean BDD-associated lesion herd prevalence of 44 % (Kofler et al. 2015, Kofler 2016, Sykora et al. 2015). In summary, these mean prevalence values had to be assessed as the tip of the iceberg in comparison to farms all over Austria. Still, based on these studies, a high prevalence of lameness could be associated for Styrian farms. Besides lameness, other metabolic diseases were common in Austrian and especially in Styrian farms. No official statistics about the prevalence of for example subacute rumen acidosis (SARA) were available, but current research was funded by Austrian funding institutions (Humer, Aschenbach et al. 2018). Therefore, it could be assumed that the prevalence of SARA has an important impact on dairy cow herd health in Austria. Regarding further metabolic diseases, the development of a new ketosis detection tool (Drössler et al. 2018) was proof of an alarmingly high prevalence of ketosis in Austrian dairy herds.

According to the Swedish study of Ingvartsen et al. (2003), animal health parameters should not be underestimated. Besides breeding goals and animal husbandry as a risk factor, nutrition constituted an important risk factor by influencing animal health parameters. Due to a lack of data, neither provided to the public by organizations subordinate to the Austrian Federal Ministry of Sustainability, Tourism and Regions nor by studies performed by national research groups, it remains unknown to which extent nutritional parameters affect animal health parameters of dairy cows in farm scenarios despite the large body of research data underpinning the role of nutrition. In this regard, the Austrian province of Styria was of special interest because of different agroecosystems and climatic zones. Another point of interest was the expected diversity in the composition of rations because especially forage feed was almost exclusively produced on-farm in this specific province. Such a kind of study, focused on nutritional and dietary aspects, was never performed before about Styria.

2.2. Influence of nutrition on productivity

Nutrition plays a big role in the productivity and health of dairy cows. Regarding feed rations, the National Research Council (NRC) set the nutritional requirements of the growing, gestating and lactating cow. These guideline values were updated the last time in 2001. Within the nutritional evaluation of rations, the dry matter intake (DMI) is a fundamental parameter to determine the total amount of nutrient intake when composing animal diets. An accurately estimated value prevents deficit and oversupply of nutrients (NRC 2001). The DMI of the high-producing cow should be high to maintain productivity that was predisposed by dairy genetics (Ledinek et al. 2019). DMI may range from 20 to 28 kg/d (Allen 2000). Deficit and oversupply of nutrients could lead to health problems, productive losses or increase the feed costs in the case of oversupply (NRC 2001). The recognized short-term regulation of feed intake depends on feed availability and feeding frequency. Both variables are affected by forage source, forage particle size and concentrate level (Allen 2000, Forbes 1985, Mazzenga et al. 2009, Tolkamp et al. 2002, Zebeli et al. 2009, Zebeli et al. 2010). In the feeding of high-yielding dairy cows, high DMI is hardly met by forages alone and concentrates are included in the diet that concentrate level may rise above 45 % of the ration (dry matter basis). A study showed that increased DMI by +3 kg milk/d/cow of concentrates led to 1.7 kg milk/d/cow more milk production (McEvoy et al. 2008). However, these energy density diets were the beginning of the pathophysiological process in the development of SARA (Krause and Oetzel 2006).

2.3. Nutrition and health

2.3.1. Nutrient composition of dairy cow diets

Dairy cow rations are composed of two sections of feed sources mainly: forage feed and concentrates. Additional minerals and vitamins are supplemented containing in commercial concentrate mixtures (Kamphues et al. 2014). More in detail, roughage, cereal grains, by-products and compound feed cover the cows' energy and nutrient requirements (FAO et al. 2014). Rations are calculated based on knowledge about the dry matter (DM) and crude fiber content of the used feedstuffs. The maintenance requirements are specified by 0.293 MJ net energy of lactation (NEL) per kg body weight$^{0.75}$ (BW) per day. Performance requirements depend on milk yield and milk composition. According to these standards, a dairy cow with 650 kg BW requires 20 kg DM, 137 MJ NEL (Kamphues et al. 2014).

Due to rumen digestion, crude protein (CP) has to be considered differently (Tab. 2). Rumen degradable protein is used in the forestomach by the microbiota and therefore, it is not provided for nutrient absorption in the small intestine directly. Nevertheless, microbial protein synthesis takes place in the rumen and microbial protein is used by the ruminant host, but sufficient microbial protein output would require enough energy intake. High crude fat (CF) and starch, that is difficult to digest by the rumen, could have a negative effect on the microbial protein synthesis. However, the rumen-undegradable protein was directly available for nutrient absorption in the small intestine. It originated from the supplemented CP and microbial protein synthesis (Kamphues et al. 2014).

Structural carbohydrate sources for herbivores are plant cell wall components containing primarily cellulose and hemicellulose. These structural substances are essential in rumen health and nutrition. Fiber stimulates rumination and salivary production, so that buffering capacity of the rumen, and the layering in the rumen is ensured. Consequently, fiber degradation and the associated short-chain fatty acid production can proceed physiologically. The content of fiber after the determination by the cooking process in neutral detergent solution (van Soest method) is named neutral detergent fiber (NDF) (Kamphues et al. 2014). At least 27-28 % of the diet DM should be aimed as NDF fraction (Erickson and Kalscheur 2020). Lignin is a non-carbohydrate, but is included in the NDF fraction together with cellulose and hemicellulose (Erickson and Kalscheur 2020, NRC 2001). NDF does not capture minor cell wall components that are solubilized like pectin, fructans β-glucan, gums and mucilage (Hall 2003, Kamphues et al. 2014). In terms of chemical analysis, acid detergent fiber (ADF) includes cellulose and lignin, representing the least digestible fiber portion of the forage (Kamphues et al. 2014). Besides the fiber content, physical effects inducing chewing activity are important for rumen health (Allen et al. 2006). Therefore, the combining term physically effective neutral detergent fiber (peNDF) was established in 2014 (Kamphues et al. 2014). The longer the fiber contained in the diet, the more chewing is stimulated and thus, more saliva production that contributes to prevention of SARA and depression in the productive performance (Brandstetter et al. 2019). A $peNDF_{>8}$ of > 18 % DM or a $peNDF_{>1.18}$ of > 32 % DM in total mixed rations (TMR) is recommended to reach optimal structural supply. The indices characterized the two fine particle sieves of the Penn State Particle Separator (values in mm). These values could also be used as benchmarks for PMRs because they are independent from performance requirements (Kamphues et al. 2014).

The non-fiber carbohydrate (NFC) fraction is a calculated value within a diet resulting from the following formula: NFC = [100 – (NDF + CP + CF + ash)]. It is a parameter that includes mostly starches and sugars. Therefore, it can indicate the concentrate feed content of a ration.

The NFC fraction should always be supplied, adapted to the current performance requirements of the cow. For lactating dairy cattle, the NRC 2001 set a maximum NFC of 36-44 % in a TMR ration (Erickson and Kalscheur 2020, NRC 2001). Current recommendations for NFC are 35 % DM in the diet (Erickson and Kalscheur 2020).

DMI is important to reach an optimal supply of energy and nutrients for maintenance and performance. The DMI capacity of dairy cows is 3-3.8 % of their BW. Under optimal conditions, it could raise to 4 % of BW. However, the highest feed intake can only be reached after reaching the top of the lactation curve. The DMI per day was stated with 16 to 26 kg DM for a lactating cow with 650 kg BW (Kamphues et al. 2014).

Tab. 2 Nutrient requirements of lactating Holstein Friesian dairy cattle (Erickson and Kalscheur 2020).

Milk production, kg	**25**	**54.4**
DM intake, kg/day	20.3	30
Energy, NEL, Mcal/kg	1.37	1.61
RDP, %	9.5	9.8
RUP, %	4.6	6.9
NDF, % min	25-33	25-33
NFC, % max	36-44	36-44

NEL = net energy of lactation, RDP = rumen degradable protein, RUP = rumen undegradable protein, NDF = neutral detergent fiber, NFC = non-fiber carbohydrates

2.3.2. Nutrition-related diseases

Achieving high productivity in dairy herds is only possible with nutrition at the optimum level, that begins at the calf and heifer age (Erickson and Kalscheur 2020). After giving birth to her first calf, the lactation, the productive period of the dairy cows starts with metabolic challenges and stress coming along (Goff 2006, Nielsen 1999). Therefore, several production-related, but also nutrition-related diseases have been reported to be common in dairy cattle herds (Bačić et al. 2007, Block 1994, Reid 1956), meaning that non-optimal nutrition is considered a risk factor for metabolic and udder health-related diseases (Ingvartsen et al. 2015, Ingvartsen and Moyes 2013) in addition to physiological hormonal changes and immunological depression of the individual cow during the periparturient and high-yielding period. Inadequacy and imbalance of nutrients in the diet would further increase the risk to develop deficiency diseases in the periparturient period (Jonker et al. 1996). Further, reduced feed intake, mainly caused by hormonal changes, leads to a negative energy balance during the early lactation period and the risk of ketosis is rising (Butler 2005).

On the opposite side, overfeeding could also have a negative impact on the physiology of the late-lactating cow. Overfeeding in the dry period leads to more body fat. Consequently, increased lipolysis happens after calving and a higher risk for ketosis can be assumed (Kamphues et al. 2014). Another crucial nutrition-related risk factor is an insufficient structural proportion in dairy cow diets. Recent studies have figured out that sufficient structural supply is necessary for adequate rumen health and to prevent SARA (Zebeli et al. 2008, Zebeli et al. 2010, Zebeli and Humer 2016).

An American study reviewed several metabolic diseases of the dairy cow during the periparturient period that is the most challenging period during the productive cycle of the dairy cow. The study gave a very good overview of the associations between nutrition and diseases (Fig. 3). A few days before parturition the feed intake of the cow is dramatically low that leads to negative energy and protein balance. Non-esterified fatty acids (NEFAs) are increasing and they can trigger ketosis or/and fatty livers. Additionally, insufficient vitamins, trace minerals or antioxidants as well as hypocalcemia coming from the high dietary cation-anion difference (DCAD) or diets with low content of magnesium (Mg) lead to immune suppression. This immune suppression facilitates the susceptibility for infectious diseases such as mastitis, retained fetal membranes and metritis. The so-called milk fever concludes the metabolic circle with a high DCAD or low Mg diet. Insufficient dietary fiber leads to displaced abomasum and rumen acidosis. Further, lameness can be caused by rumen acidosis. The accompanying low DMI closes the pathophysiological vicious circle, increasing energy disbalance at the metabolic level (Goff 2006).

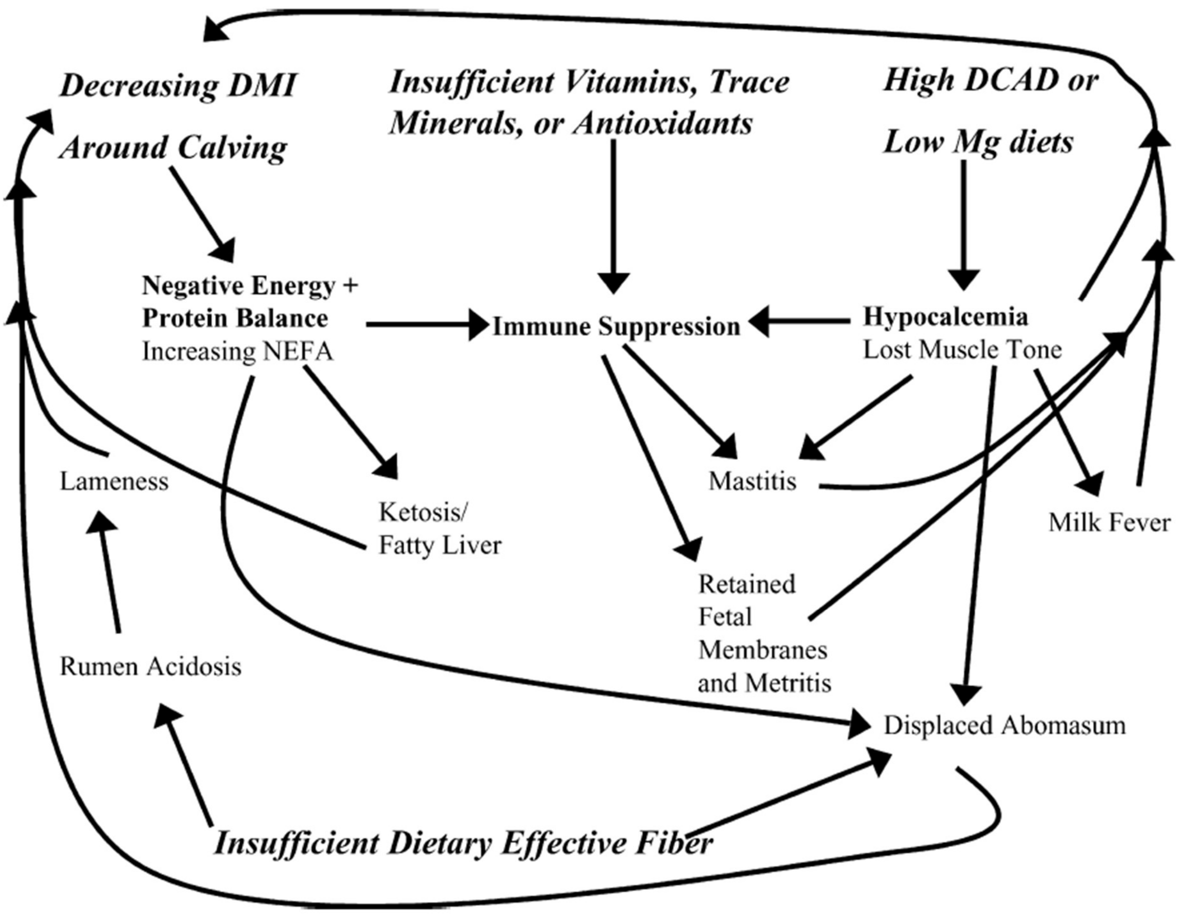

Fig. 3 Associations between nutrition and disease in the periparturient dairy cow. Key dietary factors are italicized, and key metabolic functions are in bold type (Goff 2006); DMI = dry matter intake, NEFA = non-esterified fatty acid, DCAD = dietary cation-anion difference. Mg = magnesium.

The clinical course of nutrition-related diseases is a dramatic condition of a single animal and it should be considered in discussions about animal welfare. For example, acute rumen acidosis or left displacement of the abomasum is defined as a disease with clinical courses. However, the (chronic and) subclinical course of nutrition-related diseases has an important impact on animal welfare of the whole herd, herd health and herd performance (Kamphues et al. 2014). The difficulty of subclinical diseases is the detection because clinical signs are missing or unclear to associate with a particular disease (Humer, Aschenbach et al. 2018). However, many practical ways of detection are already available for example by measuring hint values in the milk on cows that are at special risk due to their days in milk (DIM) (Drössler et al. 2018). In Austria, such measurements are routinely performed by the milk performance testing by LKV (annex 3).

One of the problematic rations are the high-concentrate diets (Pourazad et al. 2016). According to Kamphues et al. (2014), the high-risk level for SARA is already evident with an NFC proportion of > 30/35 % DM in the diet. Although high-concentrate levels are required according to the breeding potential and by the high milk yield, these high energy levels could lead to adverse health-related, specifically to a ruminal pH drop below the physiological level of 6.0 or 6.2 (Krause and Oetzel 2006). With prolonged ruminal pH suppression, SARA occurs that appears to be a common chronic metabolic disease in dairy cattle. The disease implicates enormous economic losses caused by decreased DMI, fiber digestion, milk production and feed utilization. The incidence of SARA is particularly dependent on the content of the physically effective neutral detergent fiber (peNDF), the grain source and the fermentability of the diet (Zebeli et al. 2010). For example, maize kernels are more rumen-stable than barley and wheat and should be used preferably in concentrate feed mixtures (Kamphues et al. 2014) to prevent rapid fermentation and thus ruminal pH drop. Researchers from Germany and Canada analyzed the ruminal pH cut off for the occurrence of SARA. According to the analysis in 2009, minimal risk for the incidence of SARA is given when the daily mean ruminal pH was lower than 6.16 and the time in which the ruminal pH was lower than 5.8 had been shorter than 5.24h/d (Zebeli et al. 2009). Zebeli et al. (2010) concluded that a rumen pH higher than 6.2 (daily mean) is able to prevent a potential milk fat reduction in high-yielding dairy cows. A diagnostic indicator for rumen health and fiber degradation is the milk fat proportion (Zebeli et al. 2010).

Another very important nutrition-related disease in dairy cattle is ketosis. The disease is caused by an energy deficit triggering the negative energy balance (NEB) of the early-lactating cow. The NEB is a result of a mismatch between decreased feed intake and high milk production at the same time. As a result, the blood shows high levels of ketone bodies because of an absolute or relative deficit of oxal-acetic acids. Ruminants are predisposed to the disease because carbohydrates are degraded to different short-chain fatty acids in the rumen, mainly acetate, propionate and butyrate and of these, only propionate is glucogenic. As already mentioned above, the nutritional risk factor for the development of ketosis is overfeeding of late-lactating and dry cows. It leads to increased fat deposition *pre-partum* and later to fat degradation *post-partum* when decreased feed intake happens. A pathomorphological manifestation of the disease is hepatic steatosis. Ketosis could also develop secondary when the feed intake is decreased caused by any other diseases (Kamphues et al. 2014).

Hypocalcemia is a metabolic disease that occurs *post-partum* due to imbalanced regulation of the calcium levels in the blood because of an abrupt increase of this mineral release via colostrum. Acute drop in calcium in the blood below 1.5 mmol/l leads to paresis in predisposed cows caused by breed, age and feeding. To prevent hypocalcemia, the dietary cation-anion balance (DCAB) concept was established. The concept includes the supply of strong anions, acid salts (chloride, sulfate) mostly used over the maximum period of three weeks *ante-partum* to obtain mild acidification of the metabolism that leads to an increased calcium conversion and increased sensibility of the parathormone receptors in the bones and kidneys (Kamphues et al. 2014).

Claw and limb diseases could also be triggered by imbalances of nutrients and physically effective fiber, laminitis named in particular (Fig. 4). It is a multifactorial disease especially influenced by nutrition, but could also be induced by rumen acidosis as well as bacterial diseases (*Escherichia-coli*-mastitis and purulent metritis) and environmental stress factors (cow comfort, overstocking and social stress). Production of endotoxins is triggered by ongoing generalized diseases and histamine is then released. Lesions in the ruminal mucosal wall permeate endotoxins, histamine and elevated amounts of lactic acids to enter the blood flow easier. These proinflammatory endotoxins and histamine induce degenerative and inflammatory changes and thereby lead to disturbed microcirculation in the capillaries of the dermis of the claws. The pathophysiological process eventually leads to misfunction of the fixation of the coffin bone within the suspension apparatus and the coffin bone starts to rotate distally in the typical way of laminitis (Kofler and Gasteiner 2002). For better understanding of the etiology, a Danish research group induced acute rumen acidosis by high supplementation of oligofructose in two *in vivo* experiments and proved the acute laminitis reaction by an immediate deterioration of the claw horn quality (Danscher et al. 2009, Danscher et al. 2010). Besides endotoxins and histamine, another side effect of rumen acidosis is related to subclinical biotin deficiency. Physiologically, enough biotin (vitamin H) is produced in the rumen by microbial cellulose degradation. Biotin is essential for keratinization processes. Biotin deficiency favors the occurrence of claw diseases due to reduced horn quality (soft horn) and thus, it promotes the development of horn clefts and white line defects. A further nutrition-related cause of laminitis are unbalanced rations with a high ruminal nitrogen balance and high CP content. High CP in the diet (> 18 %) combined with ruminal nitrogen balance values exceeding 50-80 g (remarkable nitrogen surplus in the rumen) have to be avoided (Kofler 2015). Finally, Kofler (2015) mentioned that mycotoxins in contaminated feedstuff are also thought to play a role in triggering laminitis.

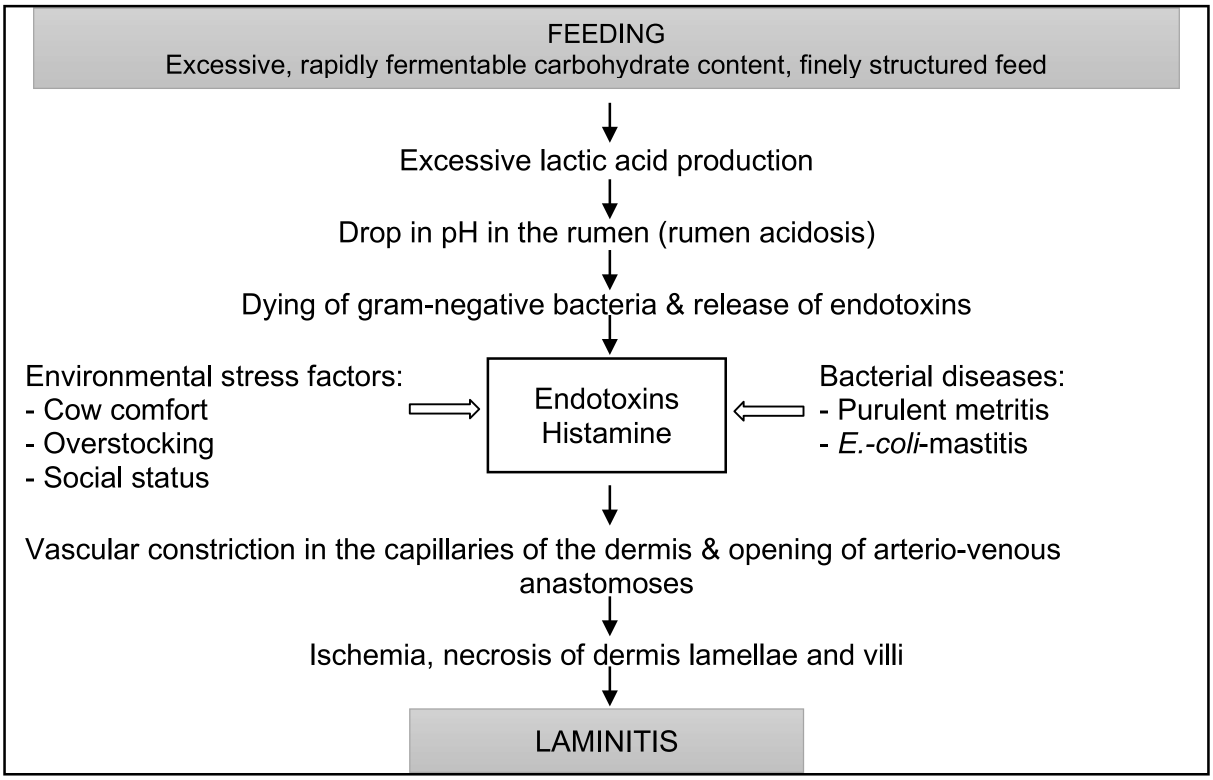

Fig. 4 Interrelationships between feeding, rumen acidosis, bacterial diseases and development of laminitis (adapted from Kofler and Gasteiner 2002); *E. coli = Escherichia coli*.

2.4. Factors affecting nutrition and feed quality

2.4.1. Feedstuff selection and feeding system

In Austrian dairy farms, three main types of feeding systems are established (percentage of farms in each feeding system): Year-round silage (40 %), green fodder plus silage (40 %) and "haymilk" (20 %). The year-round silage system has the highest contribution to the national milk production with 50 %, followed by the green fodder plus silage system with 35 % and the "haymilk" system with 15 %. The three systems only differ in the selection of roughage sources. Cereal grains, by-products and compound feed are fed about the same among all systems. The main difference between the "haymilk" system and the other two systems is the absence of silage in this kind of system. This system is also predominant in mountainous and grassland areas in the western Austrian provinces (such as Salzburg and the Tyrol). The other systems are present all over the country. Dairy cows are fed with silage-based rations throughout the year in the year-round silage system. Other than that, silage-based rations are only used during the winter season in the green fodder plus silage system and green-fodder-based rations during the other periods (FAO et al. 2014).

The FAO report 2014 showed that in Austria, the annual average feed intake was 6,252 kg DM/cow/year. Total feed intake was slightly higher in farms using the “haymilk” system (6,340 kg DM/cow/year) than the green fodder plus silage system (6,280 kg DM/cow/year) and the year-round silage system (6,205 kg DM/cow/year). Including all feeding systems, the main proportion of the diet was roughage (78 %) split between grass silage, hay, maize silage, green fodder and pasture. The second-largest proportion was represented by cereal grains (15 %). Used types were wheat, barley, maize grain, rye and oats, triticale and other grains. Compound feed (1 %) and by-products (6 %) made up the remaining 7 %. Mainly used by-products were brewery’s spent grain, sugar beet pulp, soymeal, rapeseed cake and wheat bran (FAO et al. 2014).

Three different types of rations are possible depending on the feeding technique of the farm: feeding of forage and concentrate feed components separately or mixed rations. In the partial mixed ration (PMR), the mixed part contained the forage feed sources and a balanced amount of concentrate feeds. Additionally, concentrate feed is substituted performance-depending for each cow by the separate concentrate feed dispenser. In the TMR all feed components are included. TMRs are usually provided *ad libitum* by division of the rations from four to five times a day (Kamphues et al. 2014). Mixed rations increase the DMI and increase milk yield and higher percentages of milk fat and protein in comparison to a separate pasture and concentrate feeding system (Bargo et al. 2002) and therefore PMRs and TMRs provide economic advantages.

2.4.2. Feed hygiene

Deficiencies in feed hygienic parameters are suspected to have negative impacts on nutritional status of feed, on animal productivity and health, and eventually on food safety. In general, the cause of feed hygienic deficiencies are contamination and spoilage. An overview of consequences resulting from spoilage is given in table 3. The abiotic spoilage is caused by chemical processes affecting nutrients. Predisposed feedstuff of this spoilage type are dried milk products, prone to fluctolysin (lysin + sugar) production, and fat oxidation. Abiotic spoiled feed could lead to less acceptance of the contaminated feed, diarrhea, liver pathologies and performance depression. However, the biotic spoilage of feedstuff is the more important kind of spoilage. Biotic spoilage is caused by microorganisms and its severity is influenced by their species, bacterial count and activity. Contamination by dirt, harmful rodents and their excrements as well as storage pests (insects and mites) is often involved in the micro biotic process. Regarding the feed hygiene, the hygienic status was the ideal parameter to define gradations of no, minor or massive deficiencies. According to Kamphues et al. (2014), the feedstuff is still be fed for a short time or in reduced proportions in the diet depending on the severity of the deficiency status.

Spoilage processes produce toxins as metabolites. The most important metabolites, resulting from biotic spoilage processes, are mycotoxins and they could lead to adverse health effects. The ruminant gut system copes quite well with most of the mycotoxins by inactivating them due to the activity of the rumen flora. Still, a variety of mycotoxins could pass the gut barrier and initiate health problems (Fink-Gremmels 2008a). For example, mastitis and lower leg problems in dairy cows were shown to be associated with hygienic deficient silage in a Swedish case-control study (Nyman et al. 2007). Mitigating the spoilage risk in animal feed has received research attention (Gruber-Dorninger et al. 2019). It is apparent that mycotoxins occur world-wide in different feed commodities. In the Central Europe region feed contamination with different kinds of mycotoxins was already reported (Changwa et al. 2018). Recently, an Austrian research team detected 159 different species of mycotoxins, other fungal metabolites, phytoestrogens and other metabolites across 30 sub-samples from 198 dairy rations, collected in duplicate from 100 dairy farms in Styria, Upper and Lower Austria (Penagos-Tabares, Khiaosa-Ard, Schmidt et al. 2021). The same team also reported contamination of 18 pasture samples, collected in the same Austrian provinces. 68 secondary metabolites from fungi and plants with toxic or endocrine-disrupting activities were found including emerging *Fusarium* mycotoxins, ergot alkaloids, *Alternaria* metabolites and others. Beside their occurrence, the concentration of these three mentioned emerging metabolites even showed an exponential increase exceeding from the temperature 15 °C. This fact will be a relevant consequence related to the ongoing climate change (Penagos-Tabares, Khiaosa-Ard, Nagl et al. 2021).

The occurrence of spoilage is already well studied. Still, the risk factors and the toxicological effects need more research efforts. The on-farm feed production is very common in Austria and so the diverse feeding management among farms. Feed storage is a central point of interest when it comes to bad management. This fact could be explained using silage as an example in the following. The ensiling process allows preservation of forage feed (= feed sources with high watery content) via lactic acid fermentation by maintaining the feed quality of the feedstuff. Stability in terms of preservation is reached through low pH-values. However, faulty fermentation can occur combined with mold growth and reheating. These complications have an enormous negative impact on nutrient composition and with-it on animal health (Kamphues et al. 2014). In addition to management faults, the use of byproducts in the diet poses an important feed hygienic risk factor (Moog 2012). Byproducts from the plant-based food industry are commonly used in dairy cattle diets (Kononoff 2017). The kinds of byproducts like stillage, pulp and cake vary by geographical location due to their availability (Kamphues et al. 2014, Kononoff 2017). However, byproducts are a secondary objective of agro-industrial processes (Kononoff 2017). This fact leads to the assumption that byproducts could not be properly monitored during the production process in terms of hygienic aspects, so the case of the brewery's spent grains (Johnson et al. 2010).

Tab. 3 Consequences of spoilage for the feed, the animal and the food quality (Kamphues et al. 2014).

<table>
<tr><th></th><th>Consequences for the feed</th><th colspan="2">Consequences for the animal/food quality</th></tr>
<tr><td rowspan="3">General</td><td>Changes of smell and taste, loss of physically effective fiber</td><td>Reduced feed intake, secondary</td><td rowspan="3">Consequences of too low feed intake: nutrient deficit and intoxication</td></tr>
<tr><td>Degradation of nutrients</td><td rowspan="2"></td></tr>
<tr><td>Nutrient cycling (e.g., formation of biogenic amines)</td></tr>
<tr><td rowspan="8">Specific</td><td>Increased loading of:</td><td colspan="2"></td></tr>
<tr><td>Excrements (harmful rodents)</td><td colspan="2">Infections (feed as a vector)</td></tr>
<tr><td>Storage pests (mites, insects and other)</td><td colspan="2">Reduced feed intake, mucosal irritations, allergies</td></tr>
<tr><td>Bacteria</td><td colspan="2">Infections, dysbiosis (contamination of food)</td></tr>
<tr><td>Yeasts</td><td colspan="2">Gastrointestinal gas formation</td></tr>
<tr><td>Molds</td><td colspan="2">Mycoses, dysbiosis</td></tr>
<tr><td>Toxins</td><td colspan="2">Mycotoxicosis among others (contamination of food)</td></tr>
<tr><td>Enzymes (e.g., Thiaminases)</td><td colspan="2">Nutrient deficit</td></tr>
</table>

2.4.3. Farm management and stress-inducing factors

Besides the contribution of hygiene, farm management has an impact on the nutritional status of the cow in several ways. Adequate farm management is important for maintaining animal health and productivity at the farm. Animal husbandry, feeding management and hygiene during milking are the essential parts in the overall farm management. The desirable good farm management results in healthy animals and hygienically flawless milk.

Regarding animal husbandry, all factors inducing stress have to be avoided to improve the well-being of the lactating cow. Stress depresses the immune system of the cow whereby the cows become vulnerable to diseases (Kofler and Gasteiner 2002, Nielsen 1999). Optimal stable interior equipment and stable climate are essential factors in animal well-being. In loose-house stables as well as tethering systems feeding apparatuses have to be designed optimal, besides comfortable cubicles, sufficient non-ending walkways and an efficient manure removal system. Enough feeding spots for each animal in the herd have to be installed to ensure that the feeding period is as stress-free as possible by keeping the competition for feed as low as possible (BMGF 2004). Additionally, a calm and suitable fenced compound feed station is very important in loose-house stables to ensure the concentrate feed intake especially during the high-yielding period of the cow. Next, the stocking density have to be within guidance levels (BMGF 2004). Overstocking harms the cows' well-being. There was evidence of a positive correlation between the stocking density and the dirtiness of the hind limbs (Ruud et al. 2010). Because manure is a reservoir for infectious disease stall hygiene and animal cleanliness are crucial to prevent animal diseases In this context, the cleanliness score was an established tool to assess the cleanliness of the rear, thigh, distal hind limb, udder and belly region (Ruud et al. 2010). This tool enables the assessment of the overall hygienic status of a stable and the animals' well-being status (Hauge et al. 2012). Clean cows also ensure hygienic milk production (Ruud et al. 2010). According to disease incidence, cleanliness is associated with the frequency of scrapers activity. Still, this frequency was discussed controversially in the literature. A Canadian study found out that meticulous stable hygiene was associated with lower cleanliness scores. According to this study, the scraper frequency influenced especially the dirtiness of the hind limbs and the udder (Devries et al. 2012). If the scrapers activity was set twice a day, the incidence of clinical mastitis was elevated (Peeler et al. 2000). However, another team assumed that too frequent scrapers activity led to increased claw problems because cows had to step over the scrapers more often whereby claws were almost completely covered by manure and dirt each time (Cramer et al. 2009). An Austrian study stated though, that farms using more hygiene-related measures like for example higher frequency of scrapers activity or better cubicle hygiene had cleanlier udders and teats on average (Tremetsberger et al. 2015).

As cow cleanliness is an indicator for overall stable hygiene and farm management, it provides an important hint about feed hygiene and feeding management. Adequate feeding management is important to maintain or even increase productivity. Ambitions to prevent feed impurities like dirt or even mycotoxin infestation should be present on the farm (Erickson and Kalscheur 2020). Regarding feeding management, mis-formulation of rations could lead to oversupply and deficit of the necessary nutrients, thereby affecting the productivity and productivity-related diseases as mentioned in chapter 2.3.2. For instance, mis-formulation could affect the balance between the amount of physical effective fiber and rumen fermentable carbohydrate in the rations for high-yielding cows, which is necessary to prevent SARA (Zebeli et al. 2010). Values regarding this have already been mentioned in chapter 2.3.1. Another common feeding mistake, but difficult to find out, is the incorrect calcium supplementation *ante partum* in dry cows which are at risk for hypocalcemia *postpartum*. The prevention concept has already been described in chapter 2.3.2. as well. In addition to mis-formulations, the feeding frequency has to be mentioned as an important adjusting screw in high-yielding cows. Focusing on the expected negative energy balance at the beginning of each lactation period, the increase of feeding frequency counteracted the lower feed intake (Erickson and Kalscheur 2020).

Sick animals do have not optimal production levels and cause financial losses for the farmers. Systemic illnesses decreased feed intake and milk production (Kamphues et al. 2014) as well as animal welfare (BMG 2004). Therefore, all possible measures must be taken to decrease each single risk factor that had been mentioned and thus maintain animal health and with-it productivity.

3. Materials and Methods

3.1. Selection of farms

The present study was part of the project “D4Dairy” (Digitalization, Data Integration, Detection and Decision support in Dairying) that surveyed 100 Austrian dairy farms in three different provinces including Upper Austria, Lower Austria and Styria. The inclusion criteria of farms were having a herd size of more than 50 lactating cows and having an updated registration of animal health and productive performance in the 2-year records (2017-2018) prior to the start of the D4Dairy project. The quota of farms per province was proportionately to the size of dairy production of the Austrian province. For each province, there were balanced amounts of farms with better and worse fertility performance preselected and approached. Only farms that submitted their consent were enrolled in the study. As a result, only 16 Styrian dairy farms were included in this thesis. Data of all volunteering farms were treated anonymously.

3.2. Data collection

3.2.1. Farm visits

Farm visits were performed within two weeks in August 2020. Each farm was visited once during this period. Several farm data were recorded following a face-to-face survey and feed samples were collected for analyses (Tab. 4). Documenting photos of feeding relevant locations were also taken at the farms.

Tab. 4 Summary of information collected via the face-to-face interview and on-farm observations.

General information:	• Farm type (organic vs. conventional) • Farm location (political district and sea level)
Feeding and nutrition:	• Feeding frequency • Type of rations • Diet composition • Sensory evaluation of feed quality
Hygiene:	• Sensory evaluation of feed hygiene • Cow hygiene
Cow status:	• Body condition score (BCS) • Rumen score (RS) • Fecal score (FS)

Relevant data on feeding and nutritional data were collected from the farmer based on a questionnaire (annex 4). The questionnaire included general information about the farm and the feeding management including the feeding system and the composition of the ration (Tab. 4). Furthermore, feed hygienic data was noted: usage of anti-mycotoxin-additives, hygienic conditions at the farm, cleanliness score of 20 % of the lactating cows, the hygienic status of hay, straw, silages, cereal grains and concentrate and pelleted feeds. The health status of the cows was evaluated by the fecal score, the body condition score and the rumen score. 20 % of the cows were evaluated per score. The scores were given by only one person to avoid sources of error. Based on Kamphues et al. (2014), sensory evaluation of maize and grass silage was performed at storage. The brewery's spent grain was also assessed depending on availability.

Per farm, two different types of feeds were taken namely PMR or forage and additional concentrate (Tab. 5). For PMR or forage, a 10 L bucket was filled up with hands full of samples from different spots of the feeding area. Subsequently, two samples originated from the bucket content. About 1 kg was used per sample. Firstly, a 1 kg sample was taken for nutrient composition and mycotoxin analysis. The second sample was taken for particle size determination. Ensiled brewery's spent grain, although nutritionally considered as part of concentrate, because of its wet nature and high hygienic risk, it is presented independently of concentrate ingredients, derived mostly from cereal grains, used in the basal diet and instead included in the forage fraction. For additional concentrate, the sample was taken from pelleted or not pelleted concentrate feed. All samples had to be stored vacuum-packed and frozen at -20 °C until further processing for analysis preparation (Kemboi et al. 2020). Care was taken to collect representative samples.

Tab. 5 Overview of sample collection.

Feed samples	• 1 kg of PMR or forage for nutrient composition analysis • 0.5-1 kg of PMR or forage for particle size determination • 1 kg of pelleted or non-pelleted concentrate feed

Data regarding animal health and production data used in the study were derived from the "LKV Tagesbericht" ("daily report") that was requested from the farmer directly. Originally, the data were provided from LKV Steiermark/ZAR. More details are presented in chapter 3.2.6..

3.2.2. Description of scores

All classifications were applied at 20 % of the lactating cows on a farm.

Cleanliness score:

The cleanliness scoring method of Ruud et al. (2010) was applied in this study. Five body parts underwent the score separately: the rear, the thighs, the legs, the udder and the belly. The score ranged from 1 to 4 meaning 1 = clean, 2 = some dirt, 3 = dirty or 4 = very dirty with caked-on dirt. The characteristics of each score and body part are illustrated in the scheme of figure 5.

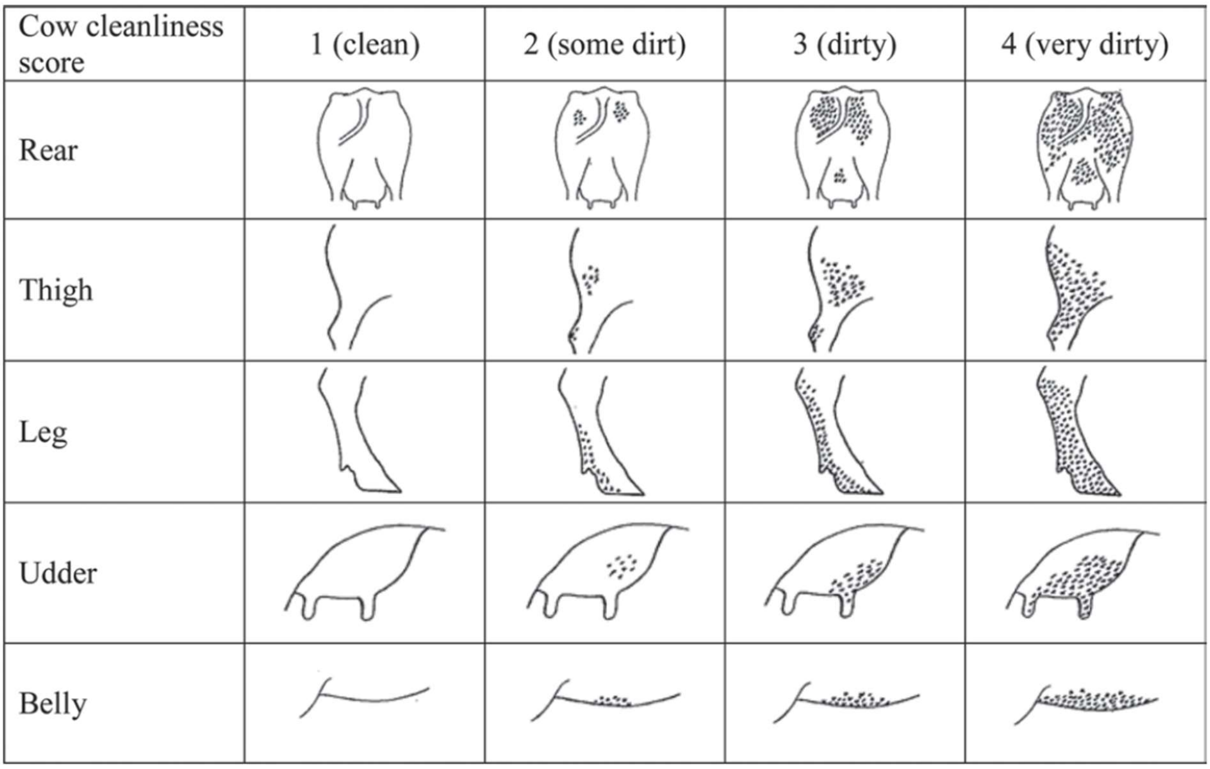

Fig. 5 Scheme for cow cleanliness scoring on the rear, thigh, leg, udder and belly (Ruud et al. 2010); 1 = clean, 2 = some dirt, 3 = dirty and 4 = very dirty.

Fecal score:

The consistency of feces was an indicator of the ratio of the number of solid substances to the amount of water. It was classified by a five-point system (Fig. 6): 1 = so watery that it is barely recognizable as dung, 2 = thin custard but recognizable as dung, 3 = thick custard, cowpat formed to a height of 2 to 3 cm, 4 = thick dung and 5 = stiff balls – similar to horse droppings (Hulsen 2007). The physiological finding of fecal consistency was pasty. But the fecal consistency and composition strongly varied depending to the composition of the feed (Baumgartner and Wittek 2018). This fact led to a physiological value of 3 within the scoring system. Score 2 and 4 could also be physiological depending on the feed.

1 (so watery that it is barely recognizable as dung.)	2 (thin custard but recognizable as dung)	3 (thick custard, cowpat formed to a height of 2 to 3cm)	4 (thick dung)	5 (stiff balls - similar to horse droppings)

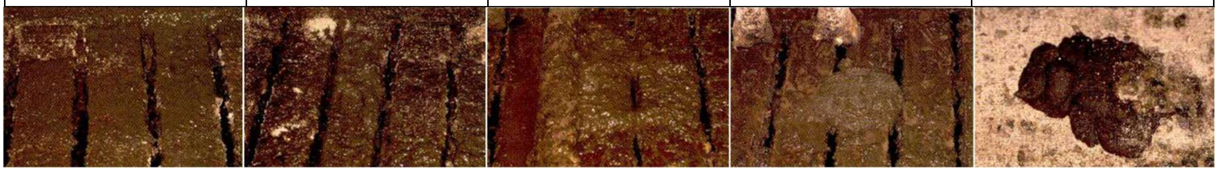

Fig. 6 Fecal score (Hulsen 2007);1 = watery, 2 = thin custard, 3 = thick custard, 4 = thick dung, 5 = stiff balls.

Body condition score:

Ferguson et al. (1994) developed a decision tree for body condition scoring of single cows (Tab. 6). The first decision point for the observer is the thurl region. This region divides the cow in BCS ≤ 3 (“V” - in appearance) or ≥ 3.25 (“U”- in appearance).

If the thurl had a “V”-shape, hook and pin bones should be observed next. BCS 3 matched, if both were rounded. If the hook bone was angular and the pin bone was round, it was a BCS of 2.75. Two angular bones meant a BCS ≤ 2.5. If the pin bone had a palpable fat pad, it was BCS 2.5, if it did not have, it was ≤ 2.25. Two parameters could be used to decide between BCS 2.5 and < 2.5. The transverse processes of the lumbar vertebrae were either visible less in half or half and more. Secondly, a rounded spine indicated BCS 2.5 and a sharp spine 2.25.

Cows with a “U”-shaped thurl region had a minimum BCS of 3.25. The hook and pin bones appeared rounded. To categorize the scores 3.25 to 4, attention was paid on the changes in the sacral and coccygeal ligaments. Distinctly visible ligaments indicated 3.25 in BCS. A BCS of 3.5 required faintly visible coccygeal ligament and a distinctly visible sacral ligament. If the visibility was the other way round, the BCS is 3.75. Both ligaments were not visible in BCS 4 (Ferguson et al. 1994).

Tab. 6 Decision chart for body condition score (Ferguson et al. 1994).

	Body region					
Body condition score	**Thurl**	**Ileal tuberosity**	**Ischial tuberosity**	**Transverse processes of lumbar vertebrae**	**Coccygeal ligament**	**Sacral ligament**
2	V	angular	angular	> 0.5 visible	visible	visible
2.25				0.25 to 0.5 visible		
2.5			fat, pad palpable			
2.75			rounded			
3		rounded				
3.25	U			0.1 to 0.25 visible		
3.5					just visible	
3.75				only tips visible	not visible	just visible
4						not visible
4.25				tips not visible		
4.5	flat			not visible		
4.75		just visible				
5	rounded	not visible				

Rumen score:

The filling condition of the rumen was assessed by the rumen score. The observer stood diagonal behind the cow. A five-point-system was used (Fig. 7). In score 1, a deep dip in the left flank was visible. The paralumbar fossa behind the last rib was more than one hand-width deep and the fossa had a rectangular appearance from the side view. Score 2 was defined by a one hand-width deep fossa and a triangular appearance. The paralumbar fossa still was just visible and showed a central, small convex skin part in score 3. The paralumbar fossa was not visible anymore in score 4 and a convex skin shape was dominating. In score 5, the lumbar vertebrae were not visible and the skin over the left side of the body was quite tight. The typical score for lactating cows was score 3 (Hulsen 2007).

1 (paralumbar fossa behind the last rib is more than one hand-width deep, rectangle shape from side view)	2 (paralumbar fossa behind the last rib is one hand-width deep, triangle shape from side view)	3 (paralumbar fossa behind the last rib is still just visible, triangle shape from side view)	4 (no paralumbar fossa visible behind the last rib)	5 (the lumbar vertebrae are not visible, no visible transition between the flank and the ribs)

Fig. 7 Rumen score (Hulsen 2007).

3.2.3. Preparation of feed samples

Except of the samples for the particle size determination, all samples needed to be prepared for different following analyses. The preparation started with the defrosting of the samples. After the determination of the DM samples went in for further preparation. Next, the dry sample was milled down to powder reached by using a Cutting Mill SM 300 (Retsch, Haan, Germany) with a 0.5 mm sieve. The sample of the concentrate was also milled, but it did not have to be dried before. The two powdered samples were filled into bags of about 30 g separately. One bag of concentrate and one bag of PMR or forage went to chemical composition analysis which was performed at the Institute of Animal Nutrition and Functional Plant Compounds.

3.2.4. Chemical analysis of basal ration (PMR or forage)

DM, ash, CP, CF, NDF and ADF were chemically analyzed following the protocol for nutrient proximate analysis of VDLUFA 2012. The NFC was calculated as follows [100 – (NDF + CP + CF + ash)]. The DM content was determined by oven drying at 100 °C for 24 hours. The determination of ash content was done by combusting the samples at 580 °C overnight. CP was determined by the Kjeldahl method. The CF was analyzed using a Soxhlet extractor (Extraction System B-811, Buchi, Flawil, Switzerland). According to Van Soest et al. (1991), the contents of NDF and ADF were analyzed separately using the Fiber Therm FT 12 (Gerhardt GmbH & Co. KG, Königswinter, Germany). The NDF was processed using a heat-stable α-amylase and both fractions were determined exclusive residual ash (Humer, Aditya et al. 2018, Kamphues et al. 2014).

3.2.5. Particle size distribution of basal ration (PMR or forage)

The Penn State Particle Separator is an established method to detect the particle size in rations. Four sieves were stacked together on top of each other. The solid pan was placed at the bottom. Above it, the sieves continued in the following order: The first sieve was the 1.18 mm one, the 8 mm sieve came in second place and the 19 mm hole size sieve went on top. Next, the PMR or forage sample was put on top, and the shaking was started according to the scheme in figure 8. The sieve set was shaken five times horizontally in a frequency of 1.1 times per second and a forward and backward motion of 17 cm. This procedure was repeated eight times with a quarter turn after each shaking circle. In total, the sample was shaken 40 times (Heinrichs 2013, Kononoff et al. 2003). Lastly, each sieve section and the solid pan section were weighed and the values were noted. Combined with the initial weight of the whole sample, the percentage of each fiber fraction could be determined. The shaking procedure was performed by the same person for all samples.

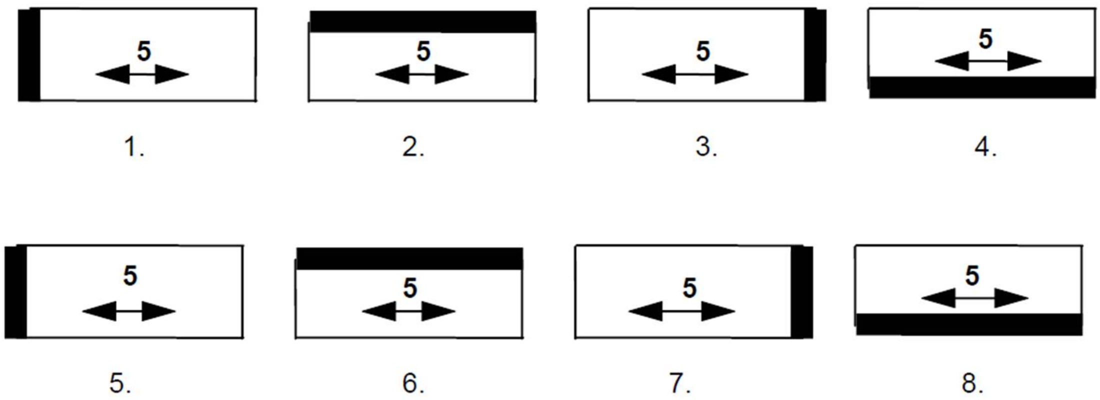

Fig. 8 Shaking pattern for particle size separation (Heinrichs 2013).

3.2.6. Data of the Federal Recording Association (LKV)

The Federal Recording Association LKV Austria Gemeinnützige GmbH is part of the Association of Austrian Cattle Breeders (ZAR) and the ZuchtData EDV Dienstleistungen Ges.m.b.H, its 100 % subsidiary. The LKV Austria was commissioned by ZAR to carry out the milk and beef performance testing and quality assurance of Austrian cattle, sheep, and goat farms. The association LKV also offers herd management support to farmers, whose are LKV members. The LKV has its headquarters in Vienna and each Austrian state has its own LKV association – so Styria does have (LKV Steiermark). All Austrian dairy farms undergo a milk performance testing nine to eleven times within a year. LKV staff takes milk samples of each single lactating cow. For each cow parameters like milk quantity, fat and protein content, somatic cell count (SCC), urea, lactose content and more are determined by LKV approved methods: The testing results are summarized in the so-called "daily report" ("Tagesbericht") and this report is sent directly to the farmer (Digitalisierung in der Landwirtschaft, LKV Austria 2020, Zentrale Arbeitsgemeinschaft Österreichischer Rinderzüchter). Detailed information about the "daily report" is given in the following.

The "daily report" contains the following information: results of the particular sampling, control results after performance classes for feed consultation, moving farm average, change in livestock since the last control (usage of the livestock market data from Agrar Markt Austria) and a summary of the performance data. This summary includes the current calculated performance data of lactating cows and a list of heifers with breeding maturity. A "daily report" example is provided in annex 3 (LKV Austria 2020). The report is structured in ten parts listed in Tab. 7. It gives a compact overview of the productive, management and animal health situation of an Austrian farm. Parts used in the present study are described in the following.

In point one, each single cow is listed with its milk sample results in one row. Therefore, each cow was identified by its number within the farm, the cow's name and its 11-digits life number. Subsequently, the following values are allocated to each identified cow within the list: parity, DIM, milk quantity of the last milk testing, milk quantity of the current milk testing, fat and protein proportion, SCC, fat-protein-quotient, urea and class number of the urea-protein-quotient. The list is completed by one row of average values. The total average was calculated as well as the average per breed. The variation in comparison with the last milk testing is placed below the total average row. Part three gives important hints about herd management of the past three months including the numbers of cows that require special attention from the farmer referred to udder health, feeding and metabolism, reproduction, and others. Additionally, hints referring to calves, heifers and bulls are listed to complete a comprehensive herd management overview. One specific value is the KetoMIR value (= risk of ketosis from milk mean infrared (MIR) spectrum measurement) that is a quite new technology used for the detection of the risk for ketosis of each individual cow (Doherr et al. 2008, Werner et al. 2019). This value is the only long-term value within this section. In points four to seven, the information given in point three is presented more in detail and abnormal data specifically per cow. Point ten presents the graphical depiction of the results. The graph showing urea and protein is the so-called 9-fields-board. It results from a categorization according to the energy and protein supply. The fat-protein quotient graph shows the cows risk for ketosis or acidosis depending on the number of DIM. The third graph shows each cow in the context of excess energy and energy deficit with its line of tendency (Hausegger and Auer 2014).

Tab. 7 Structure of the "daily report" (Hausegger and Auer 2014).

1st	Results of milk samples
2nd	Moving farm average
3rd	Important hints about farm management
4th	Udder health
5th	Feeding and metabolism
6th	Further information
7th	Overview of diagnoses and observations within the last three months
8th	Overview of production data
9th	Change in livestock since last control
10th	Graphical depiction of results

The “daily reports” used in the present study were dated as close as possible to the farm visit day. Accordingly, they corresponded to the samplings of July and August 2020. The results of the milk testing, the farm management data and the feeding and metabolic part were of main interest in this thesis. It was objective animal health and productive farm data provided by LKV-Steiermark/ZAR.

3.2.7. Statistical analyses

Descriptive statistical analyses of the study, as well as graphical results, were done using Microsoft Excel®. To evaluate intercorrelation between feeding and nutritional status with health and productive data of dairy cow, a principal component (PRINCOMP) analysis was performed using the PRINCOMP procedure of SAS® (version 9.4, SAS Institute Inc., Cary, NC, USA). Because variables were measured in different units the correlation matrix was used to generate principal component eigenvalues and the loading plots. The relationship of potential pairs was investigated using a simple linear regression using the generalized linear model procedure (Proc GLM) (version 9.4, SAS Institute Inc., Cary, NC, USA). A non-linear relationship was fitted following a power function using the non-linear procedure (Proc NLIN) of SAS® (version 9.4, SAS Institute Inc., Cary, NC, USA). Regression equations, R^2 for linear regression and RMSE (root mean square error) for non-linear regression are reported along with the data and the regression line.

4. Results

4.1. Farm characteristics

4.1.1. Geography and farming systems

Geographically, the 16 Styrian farms were distributed in five different political districts (Tab. 8). Five farms each were located in Hartberg-Fürstenfeld as well as in Liezen. Four farms were located in Leoben and one farm each in Graz-Umgebung and Murau. The attitude ranged from 503 to 1105 m above sea level with a mean of 698.13 and a SD of 136.36 m. Out of the 16 farms, 14 farms used the conventional farming system and two farms worked under organic farming conditions.

Tab. 8 Farm locations and farming system.

Farm code	Political district	Attitude (m)*	Farming system
ST-01	Leoben	715.00	Conventional
ST-02	Leoben	713.00	Conventional
ST-03	Liezen	803.00	Conventional
ST-04	Hartberg-Fürstenfeld	681.00	Conventional
ST-05	Hartberg-Fürstenfeld	588.00	Conventional
ST-06	Liezen	651.00	Conventional
ST-07	Leoben	671.00	Conventional
ST-08	Graz-Umgebung	575.00	Conventional
ST-09	Hartberg-Fürstenfeld	591.00	Conventional
ST-10	Murau	**1105.00**	Organic
ST-11	Leoben	627.00	Conventional
ST-12	Hartberg-Fürstenfeld	**503.00**	Organic
ST-13	Liezen	660.00	Conventional
ST-14	Liezen	726.00	Conventional
ST-15	Liezen	759.00	Conventional
ST-16	Hartberg-Fürstenfeld	802.00	Conventional
Mean		698.13	
SD		136.36	

ST = Styria, * = source: (Google Maps).

The lowest data marked in bold and maximal values in bold red letter.

4.1.2. Milk production and breeds

The number of lactating cows per farm and the average milk production per day per cow per farm including milk components is shown in figure 9. The farm size ranged from 37 to 71 lactating cows per farm with a mean of 50.4 (SD = 9.96). Farms showed substantial differences in the average milk production per day per cow ranging from 21.5 to 32.9 kg milk/d/cow and a mean of 27.66 kg milk/d/cow (SD = 3.6 kg milk/d/cow). The farms ST-10 and ST-12, that were organic, had the lowest values in milk production (21.5 kg milk/d/cow and 21.9 kg milk/d/cow, respectively). The milk protein content was quite similar among all farms, of which the majority showed about 3.5 %. The average milk protein was of 3.43 % (SD = 0.1 %). The two organic farms with low milk yields also showed low milk protein (3.24 % and 3.25 %). The milk fat content, however, more fluctuated among the farms ranging from 3.9 % to 4.44 % and a mean of 4.1 % (SD = 0.2 %). The milk fat was above the overall median of 4.05 % in farm ST-12 (4.1 %), and below the median in farm ST-10 (3.96 %).

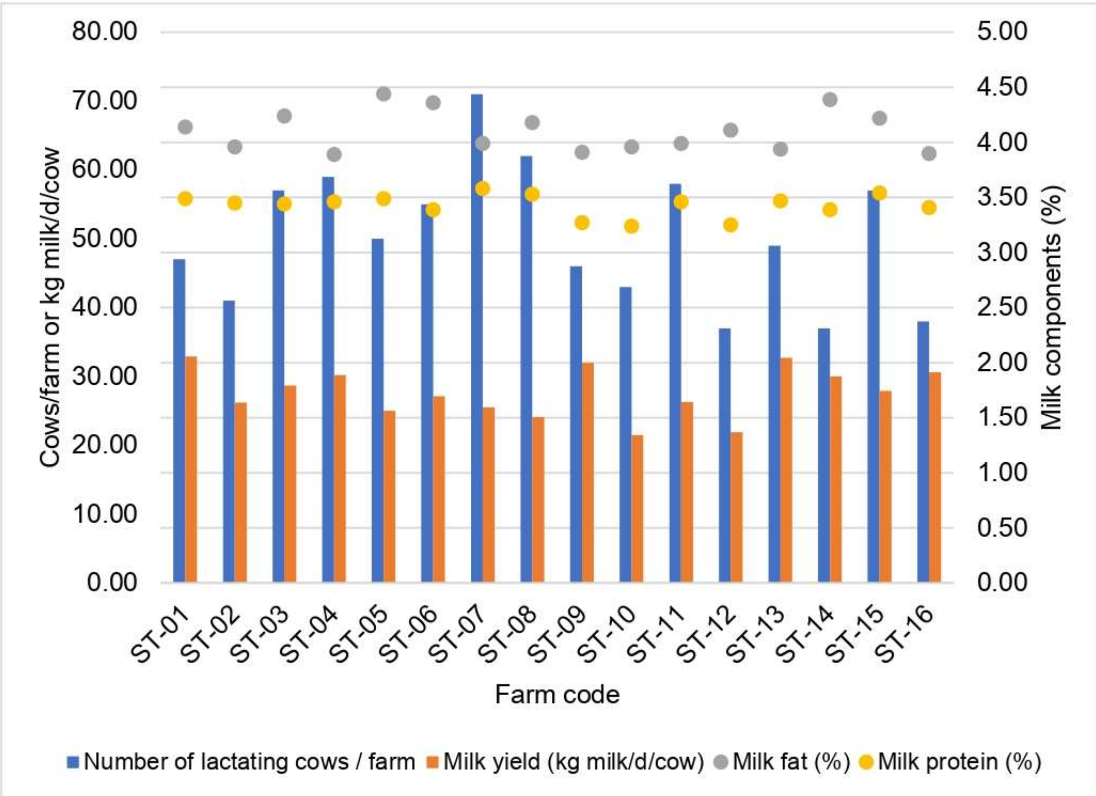

Fig. 9 Number of lactating cows per farm and milk production per day per cow per farm including milk components in Styrian farms; SD = standard deviation, d = day, ST = Styria.

On average across all farms, the FV breed was dominant in 69 % of the herds and HF in 19 %. The rest of 12 % were BS and BS + HF (Fig. 10). When separated by farm, a variety among the farms concerning the composition of cow breeds was observed (Fig. 11). Specifically, six farms used exclusively FV cows and one farm BS. The remaining nine farms used multiple breeds in the herds. Three farms (ST-01, 07 and 14) had HF dominated herds, while FV was the main breed of ST-04, 05 and 08.

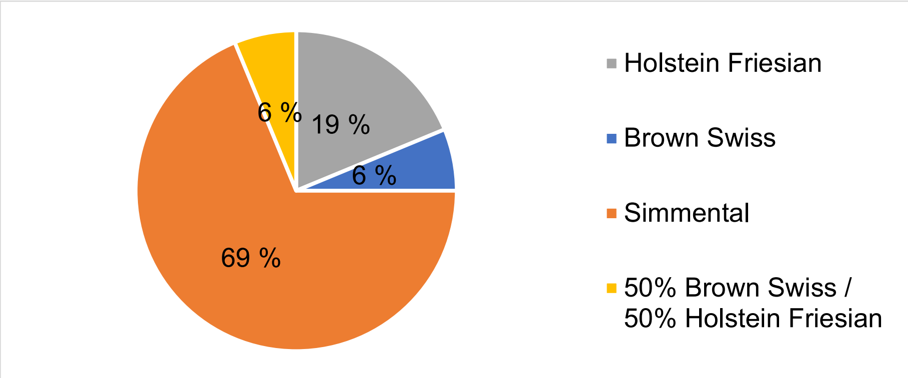

Fig. 10 Main breed in Styrian dairy farms (%).

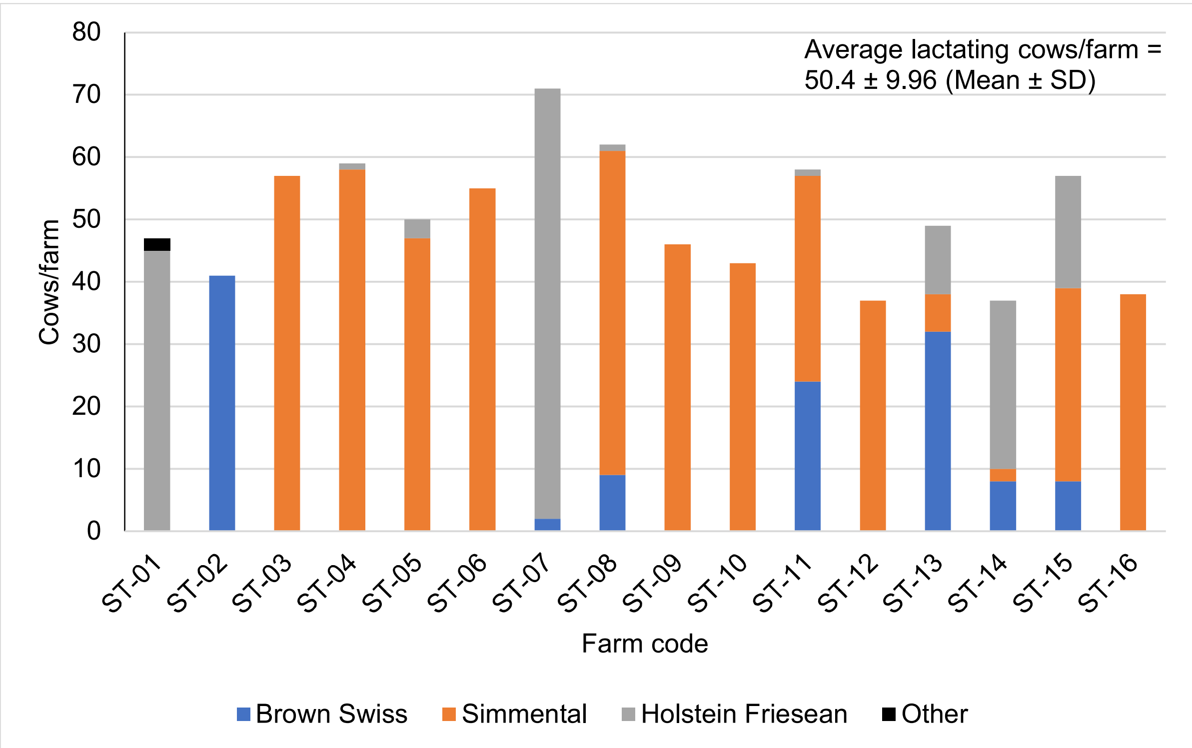

Fig. 11 Composition of cow breeds per farm; SD = standard deviation, ST = Styria.

4.1.3. General feeding practices

Facts of general feeding practice are given in table 9. There were two types of ration among farms. The PMR was used at twelve farms, which was the majority. Four farms used forage (ST-02, 06, 10 and 12). Most farms offered feed once a day. Only three farms managed the feeding in different feeding frequencies. Accordingly, farm ST-04 offered feed three times in two days while the farms ST-09 and 10 offered feed more frequently. Both using a feeding robot, they fed five times and twice a day, respectively. Along with indoor feeding, some farms also incorporated grazing for their lactating cows.

Tab. 9 General feeding practice of the 16 study farms.

Farm code	Type of ration	Feeding frequency	Grazing for
ST-01	PMR	1	Heifers
ST-02	Forage	1	**All the animals**
ST-03	PMR	1	Heifers
ST-04	PMR	1.5	No grazing
ST-05	PMR	1	Heifers
ST-06	Forage	1	No grazing
ST-07	PMR	1	Heifers
ST-08	PMR	1	No grazing
ST-09	PMR	5	Dry Cows
ST-10	Forage	2	**All the animals**
ST-11	PMR	1	**Cows and heifers**
ST-12	Forage	1	**Lactating cows**
ST-13	PMR	1	Heifers
ST-14	PMR	1	Dry cows
ST-15	PMR	1	Heifers
ST-16	PMR	1	Heifers

PMR = partial mixed ration, ST = Styria.

Bold = Farms included grazing as part of the diet of lactating cows.

Regarding forage feed types, all farms used grass silage as the main forage in the ration (Tab. 10), but managed the storage differently. Twelve farms stored the grass silage in bunker silos. The farms ST-05, 13 and 14 used round bales only. Farm ST-12 used both types of storage. Five farms used silage additives in this type of silage (ST-01, 04, 08, 09 and 11). At four farms (ST-03, 09, 12 and 15), mold was present at grass silage storage. Thirteen farms fed maize silage stored in bunker silos. Of these, five farms treated their maize silage with silage additives (ST-01, 08, 09, 11 and 16). The presence of mold in maize silages was positive in five farms (ST-03, 04, 06, 09 and 15) and negative in eight farms (ST-01, 02, 05, 07, 08, 11, 14 and 16). The three farms ST-10, 12 and 13 did not use maize silage. Ten farms used the sandwich method combining grass and maize silage in bunker silos, while farm ST-03 stored grass and maize silage separately. One farm (ST-14) used different types of silo. As additional silage, brewery’s spent grain was also used at five farms (ST-01, 02, 03, 14 and 15). There was no mold visually detected in this silage type.

Tab. 10 Types of forage feed sources.

Farm code	Maize silage	Grass silage	Other silage type
ST-01	Yes	Yes	Brewery's spent grain
ST-02	Yes	Yes	Brewery's spent grain
ST-03	Yes	Yes	Brewery's spent grain
ST-04	Yes	Yes	No
ST-05	Yes	Yes	No
ST-06	Yes	Yes	No
ST-07	Yes	Yes	No
ST-08	Yes	Yes	No
ST-09	Yes	Yes	No
ST-10	No	Yes	No
ST-11	Yes	Yes	No
ST-12	No	Yes	No
ST-13	No	Yes	No
ST-14	Yes	Yes	Brewery's spent grain
ST-15	Yes	Yes	Brewery's spent grain
ST-16	Yes	Yes	No

ST = Styria.

The type and portion of concentrate differed among farms (Tab. 11). There were two types of concentrate, one that was mixed into the PMR and the additional one, mostly pelleted commercial that was fed separately per individual cows depending on the DIM at all farms. Among the farms using PMR, seven farms used only one type of concentrate added in PMR (ST-03, 07, 10, 11, 14, 15 and 16) and six farms used both types (ST-01, 04, 05, 08, 09 and 13). Being an exception, farm ST-10 used a different method of concentrate feeding. At this specific farm, the farmer distributed the concentrate by hand at the feeding table once a day and the exact amount of concentrate could not be determined at the farm visit. Six farms used a grain mix in the PMR (ST-07, 10, 11, 14, 15, and 16), five farms used a grain mix and protein feed (ST-01, 04, 05, 09 and 13), one farm used maize and protein feed (ST-08) and one farm used only protein feed (ST-04).

Tab. 11 Types of concentrate feed sources.

Farm code	Type of ration	Type of concentrate feed in PMR	Type of concentrate feed at additional station
ST-01	PMR	Grain mix + protein feed	Pelleted-commercial
ST-02	Forage	N/A	Pelleted-commercial
ST-03	PMR	Protein feed	Pelleted-commercial
ST-04	PMR	Grain mix + protein feed	Pelleted-commercial
ST-05	PMR	Grain mix + protein feed	Pelleted-commercial
ST-06	Forage	N/A	Pelleted-commercial
ST-07	PMR	Grain mix	Pelleted-commercial
ST-08	PMR	Maize + protein feed	Grain mix + pelleted-commercial
ST-09	PMR	Grain mix + protein feed	Pelleted-commercial
ST-10	Forage	Grain mix	Pelleted-commercial
ST-11	PMR	Grain mix	Pelleted-commercial
ST-12	Forage	N/A	Pelleted-commercial
ST-13	PMR	Grain mix + protein feed	Pelleted-commercial
ST-14	PMR	Grain mix	Pelleted-commercial
ST-15	PMR	Grain mix	Pelleted-commercial
ST-16	PMR	Grain mix	Pelleted-commercial

PMR = partial mixed ration, N/A = not available, ST = Styria.

4.2. Feed intake and nutritional composition of the diets

4.2.1. Basal rations (PMR or forage)

4.2.1.1. Ingredient composition

The ingredient composition of the diets and estimated feed intake of the diets were recorded from all 16 farms. It was not possible to estimate the amount of feed intake associated with grazing included in the thesis, however, the majority of farms did not include grazing for their lactating cows or only in small contributions. The exception was farm ST-10 that showed extremely low estimated feed intake of the offered forage (9.41 kg total DMI/d) because of the disproportionate amount of grazing in the full ration. Thus, the feed intake data and analysis related to feed intake cannot be made reasonably for his farm. The results reported here, therefore, originated from 15 farms. Data are reported on a DM basis.

The boxplots in figure 12 show the distribution of forage feeds in the basal diet and the amount of additional concentrate in total ration with the 15 farms. The main forages included in the basal diet were maize silage, grass silage and straw. The maize silage proportion in the basal diet varied from 0 up to 44.2 % with a mean of 25.3 % and a median of 34.2 %. The grass silage proportion ranged from 26.1 to 100 %. The mean of grass silage was 60 % and the median was 57 %. The proportion of straw, used in seven farms (ST-04, 05, 06, 09, 11, 14 and 15), ranged from 0 to 3.3 % among all farms. The mean was 0.5 % and the median was 0 %. Brewery's spent grain was used in five farms (ST-01, 02, 03, 14 and 15). Among all farms, the proportion ranged from 0 to 14.4 % with a mean of 3.2 % and a median of 0 %. In a total diet, additional concentrate was used from 0 % to 13.5 % with a mean of 6.6 % and a median of 7.02 %. The forage to concentrate ratio of the total diet ranged from 46:54 (ST-11) to 87:13 (ST-12). The average ratio across the farms was 68:32.

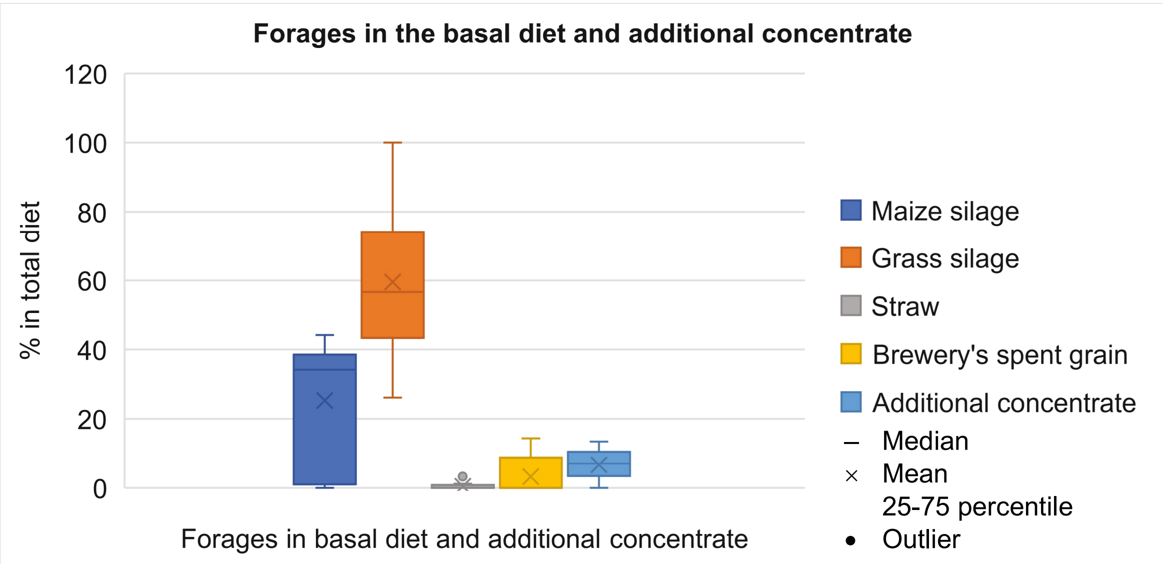

Fig. 12 Ingredient composition of the basal diet.

Some farms used further forage and concentrate ingredients, but represented minor components in the ration. Two farms (ST-02 and 16) included hay in the ration (13 % and 1.2 %, respectively). Farm ST-14 also fed hay but it was separate from the PMR. The amount was 1.5 kg/cow/day. Farm ST-02 used an additional silage mix containing peas, sunflowers, clover, and rye whole plant (17.4 %) in the diet. Water was added to the PMR at five farms (ST-01, 04, 09, 11 and 13) with proportions from 1.4 to 11.5 % of the PMR. 1.9 % of beet pulp silage was included in the diet at farm ST-09. Three farms (ST-01, 04 and 07) used propionic acid with proportions from 0.06 to 0.2 % in the PMR. Molasses was used in the PMR (1.1 % and 0.7 %) at the two farms ST-04 and ST-11 and mineral supplements were used at eight farms (ST-05, 06, 07, 10, 11, 13, 14 and 15) ranging from 0.1 to 0.4 % of the PMR. 0.2 % of salt was additionally used in the PMR at farm ST-07. Farm ST-13 included 0.1 % of IPUSagro F staubreduziert® in the PMR and farm ST-08 included corn kernels in the PMR.

4.2.1.2. Nutrient composition of basal ration (PMR or forage)

Via chemical analysis, nutrient parameters were determined (Fig. 13). All nutrient parameters resulted in wide variety among the 16 study farms. The DM content showed a range from 31.4 to 41 %. NFC and NDF showed wide ranges of 50 to 71 % and 0.8 to of 24.4 % (DM basis). The other parameters also resulted in wide scattered values. With the organic matter (OM) differed much less among the farms, ranging within 93 and 95.5 % of basal DM. Further, CP, crude ash and CF showed on a DM basis ranges of 13.2-18.8 %, 5.6-1.7 % and 2.8-4.2 %, respectively.

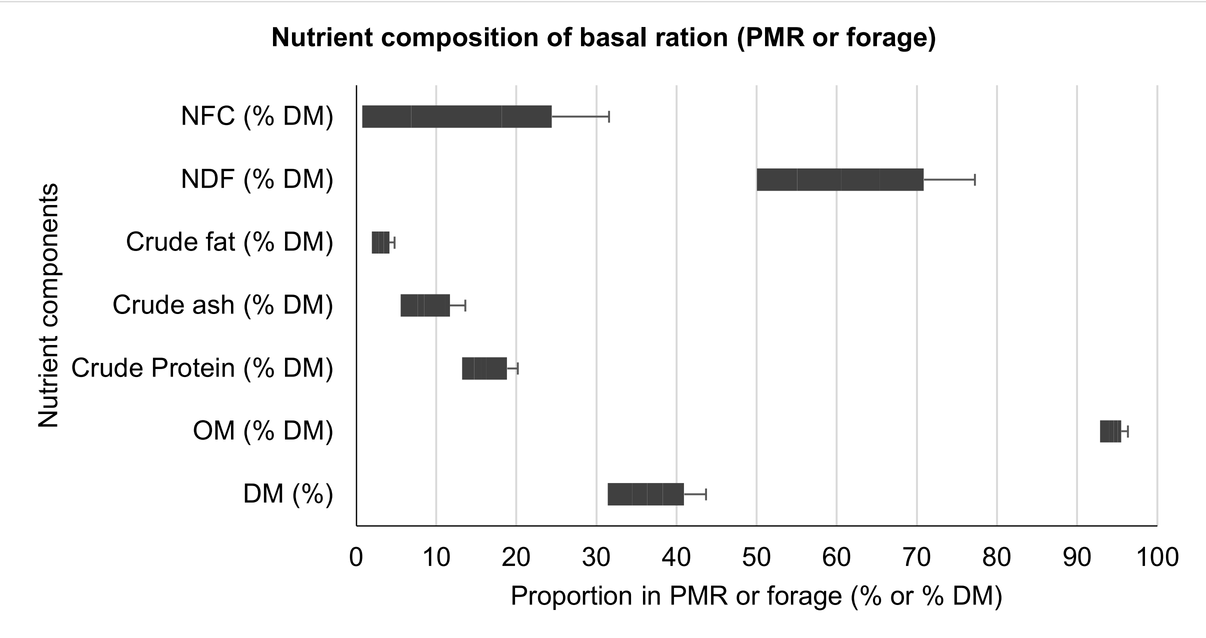

Fig. 13 Nutrient composition of basal rations (PMR or forage); PMR = partial mixed ration, NFC = non-fiber carbohydrate, NDF = neutral detergent fiber, OM = organic matter, DM = dry matter.

4.2.1.3. Particle size distribution of basal ration (PMR or forage)

PMR or forage samples were analyzed by the Penn State Particle Separator. After the performance, according to the shaking pattern, four particle size sections were determined per sample (Fig. 14). All particle size sections showed a wide variety in their percentage values. The organic farms (ST-10 and 12) had the highest percentages (96.1 % and 92.3 %) of the long particle section (> 19 mm) and they had the lowest percentages among all farms in the remaining particle size sections with values only ranging from 0.4 % (ST-10; < 1.18 mm particle size section) to 4 % (ST-12; 1.18-8 mm particle size section). The highest percentages (10 % and 13 %) of the fine particle section (< 1.18 mm) were observed at the farms ST-09 and ST-13. Consequently, the long particle section (> 19 mm) was lower represented within the rations of these two farms. The percentages of the long particle size section (> 19 mm) were close to the median of 51 % (47.3 % and 63 %). Additionally, a big variation was shown within the 1.18-8 mm and 8-19 mm particle size sections (1.6-43.2 % and 2-41.3 %). The lowest percentages were still represented by the two organic farms within the two medium particle size sections.

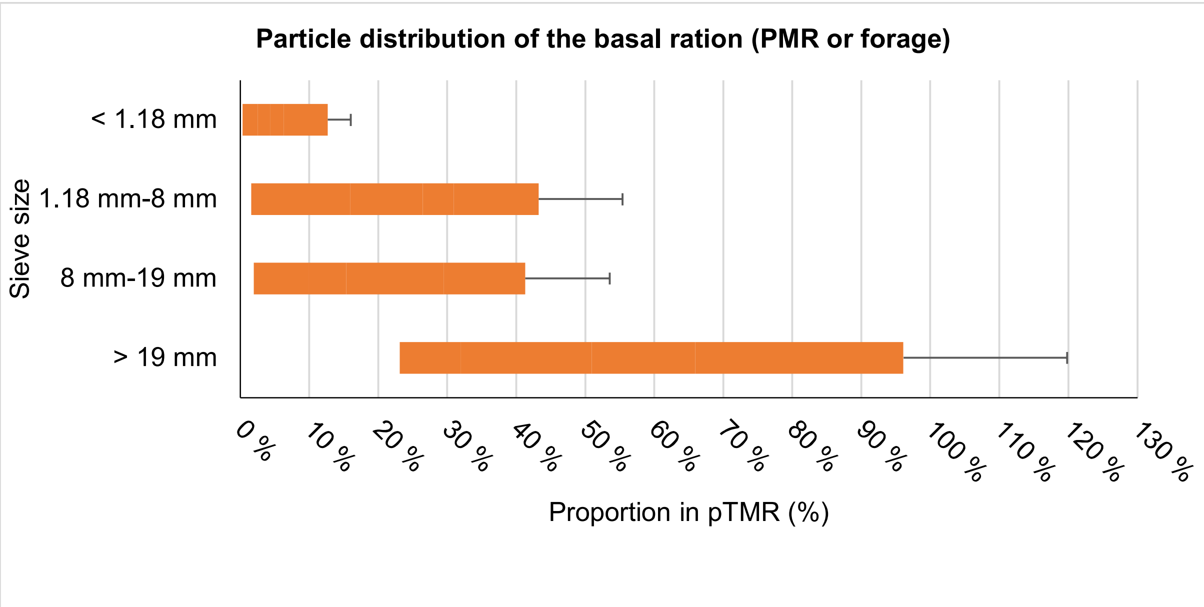

Fig. 14 Particle distribution of basal rations (PMR or forage); PMR = partial mixed ration.

4.2.2. Feed intake

The estimated total feed intake was the sum of intake of PMR plus the additional concentrate intake (DM basis). The feed intake data of farm ST-10 could not be adequately estimated because of the intensive utilization of grazing. As shown in figure 15a below, the total DM intake among the 15 remaining farms ranged from 18.9 to 27.4 kg DM/d. The basal feed intake varied between the 15 farms by about 10 kg DM/d beginning from 14.3 kg DM/d and 24.2 kg DM/d being an outlier, though. The additional concentrate was within 2.7 and 6.3 kg DM/d varying around 3 kg DM/d. In addition to the absolute feed intake values (kg DM/d), the proportional values of the main feed sources in the total diet DM were calculated (Fig. 15b). The forage and concentrate proportions in the total diet DM highly differed among the farms, both feed components even having outliers in both directions. The maximum proportion of forage (86.8 %) at the organic farm ST-12 was almost twice as high as the minimum proportion (46.3 %) at farm ST-11. As expected, the maximum and minimum values behave exactly the other way round for the percentage of concentrate in the total diet DM. The lowest concentrate feed proportion (13.2 %) was observed at the organic farm and the highest proportion (53.8 %) at farm ST-11. The variation of the additional concentrate proportions was also high (11.5-27.4 %), but without outliers. Mean and median were close to each other in all boxplots in both graphs.

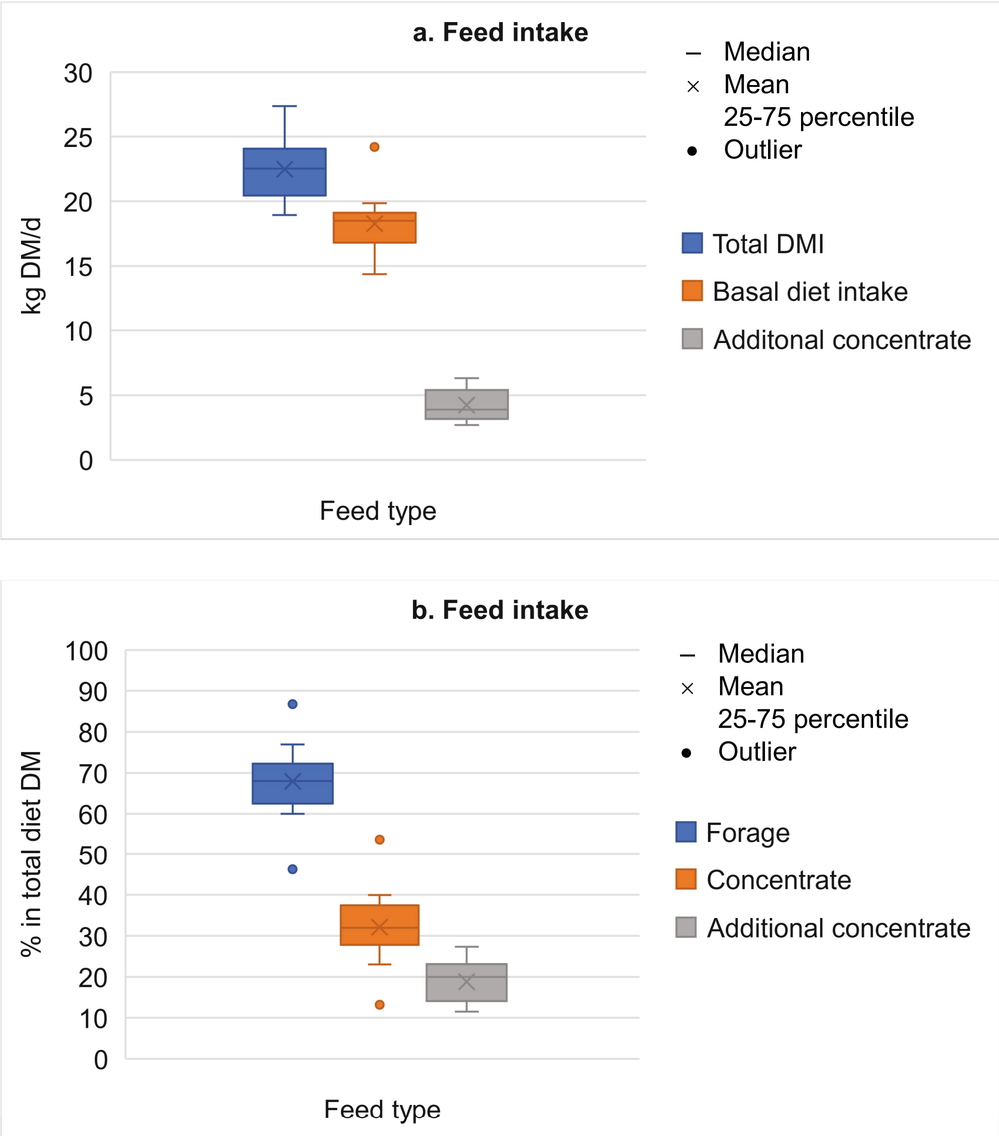

Fig. 15 Feed intake; DM = dry matter, d = day, DMI = dry matter intake.

4.3. Hygienic parameters of farm management

4.3.1. Quality and hygiene of storage feed

The sensory evaluation of the main forages and the concentrate feed included several parameters like color, impurities, odor and texture was a semiquantitative classification. Regarding to feed quality, grass silage was of satisfying quality at most of the farms. Three farms used grass silage of very good to good quality (ST-04, 06 and 09). The maize silage was of satisfying quality at seven farms (ST-01, 02, 04, 08, 11, 14 and 15). Maize silage of very good to good quality was evaluated at five farms (ST-03, 06, 07, 09 and 16). Four of the farms fed brewery's spent grain of very good to good quality (ST-01, 03, 14 and 15). This type of silage was of satisfying quality at farm ST-02. Two farms (ST-01 and 08) fed different additional silage types that were of very good to good quality at both farms. At farm ST-01, it was a silage mix containing peas, sunflowers, clover and rye whole plant. The second farm feds corn kernels (ST-08). Straw of satisfying quality was fed at the farms ST-04, 05 and 14. Four farms fed very good to good quality straw (ST-06, 09, 11 and 15). Hay of satisfying quality was part of the diet at farm ST-14. Farms ST-02 and ST-16 fed very good to good quality hay. Except farm ST-02 that concentrate scored as satisfying quality, the quality of concentrate feed was very good to good at all other farms.

The feed hygienic status was determined for each feed source. 51.3 % of all evaluated silage samples were of proper hygiene. Grass silage with proper feed hygiene was used at half of the farms (ST-02, 04, 06, 07, 09, 13, 14 and 16), maize silage was of proper hygienic level at seven farms (ST-01, 02, 06, 07, 08, 14 and 16), four farms fed brewery's spent grain of proper hygienic level and the silage-mix at farm ST-01 and the corn kernels at farm ST-08 also were of proper feed hygiene. However, minor feed hygiene deficiencies were detected in the silages of 10 farms (ST-01, 03, 04, 05, 08, 09, 10, 11, 12 and 15). Three farms used grass silage of minor deficient hygiene (ST-03, 05 and 11). Significant deficiency of feed hygiene was detected at four farms (ST-01, 10, 12, and 15) and at farm ST-08, the feed hygiene of grass silage was assessed with vast deficiency. Maize silage was of minor deficient hygiene at five farms (ST-03, 04, 09, 11 and 15) Farm ST-03 had brewery's spent grain with minor deficiency. The hygienic status of straw was proper at most farms using this structure rich and nutrient poor kind of forage. Farm ST-04 had a minor deficiency status in straw. ST-02 and ST-14 fed hay with minor deficient hygiene and the hay at ST-16 showed the proper hygiene status. Nearly all farms used concentrate feed with proper hygienic status except of farm ST-02 assessed with a vast deficiency status.

4.3.2. Cleanliness score

The results of the cleanliness score are shown in Tab. 12a. The cleanliness score was assessed from the rear, the thigh, the legs, the udder and the belly with scores from 1 to 5, 1 meaning visually clean and 5 meaning unacceptably dirty (Hulsen 2007). The mean total cleanliness score among all farms was 2.34 (SD = 0.46). Overall, cows were relatively clean with a median of total cleanliness of 2.2. The majority of farms scored a total score below 3 and four farms below 2. Farm ST-13 stood out having exceptional high scores compared to the other farms with scores of all parts exceeding 3, except belly and udder and thus had a total score of 3.46. Among all assessed aspects of the cow, the rear and thigh showed the highest variations with SDs of 0.71 and 0.69. Legs were the dirtiest body parts with a mean of 3.16, while on average, the scores of other evaluated body parts stayed below 3. Farm ST-01 had the lowest total cleanliness score (1.8). It also had the lowest score in the category legs (2.2). At farm ST-02, rears and thighs had the lowest scores (1.1 and 1.2). The same farm had the highest score in the belly region (2.6). The lowest udder cleanliness score was detected at farm ST-06 (1.25) and the belly region was scored the lowest at farm ST-08 (1.15).

4.4. Health and productive data

4.4.1. Cow status (BCS, RS and FS)

The score results of fresh feces, body condition and the rumen are listed in Tab. 12b. Nine farms showed the optimum of score 3 in the fecal score. The other seven farms had fecal scores below score 3 (ST-02, 04, 07, 09, 10 and 13). ST-04 had the lowest fecal score with the farm average score of 2.58. The variation in the fecal score was very small among the farms with a mean of 2.93 (SD = 0.13). The BCS differed a lot more with a mean of 3.27 (SD = 0.34). Three farms (ST-02, 07, and 14) were below score 3. The lowest average BCS was assessed at farm ST-14 (2.58) and the highest BCS had farm ST-05 (3.64). Among all score parameters, the smallest variation had the rumen score with a mean of 3.01 (SD = 0.05). The lowest and the highest rumen score were detected at farm ST-16 (2.9) and farm ST-03 (3.09).

Tab. 12a Cleanliness score, **b** Fecal score (FS), body condition score (BCS) and rumen score (RS).

a. Farm code	Rear	Thigh	Legs	Udder	Belly	Total
ST-01	2.07	1.80	**2.20**	1.40	1.53	**1.80**
ST-02	**1.10**	**1.20**	3.30	2.10	**2.60**	2.06
ST-03	2.18	1.64	3.09	1.82	1.55	2.05
ST-04	2.58	1.58	2.42	1.83	1.25	1.93
ST-05	2.45	1.55	2.64	1.36	1.27	1.85
ST-06	2.75	1.58	2.83	**1.25**	1.00	1.88
ST-07	1.80	1.80	3.47	2.07	1.87	2.20
ST-08	3.15	2.15	2.85	1.62	**1.15**	2.18
ST-09	3.50	2.90	3.70	2.30	1.80	2.84
ST-10	2.90	1.90	2.80	2.00	1.40	2.20
ST-11	3.07	2.64	3.21	2.50	2.00	2.69
ST-12	3.18	2.73	3.45	2.09	2.45	2.78
ST-13	**4.00**	**3.90**	**3.80**	**3.00**	**2.60**	**3.46**
ST-14	2.40	2.50	3.30	1.30	1.60	2.22
ST-15	3.19	2.75	3.56	2.31	2.13	2.79
ST-16	2.30	2.30	3.40	2.10	2.50	2.52
Mean	2.66	2.18	3.13	1.94	1.79	2.34
SD	0.71	0.69	0.46	0.48	0.54	0.46

b. FS	BCS	RS
3.07	3.33	3.07
2.70	2.68	3.00
3.00	3.50	3.09
2.58	3.52	3.08
3.00	3.64	3.00
3.00	3.54	2.92
2.80	2.82	3.00
3.00	3.56	3.00
2.90	3.50	3.00
2.90	3.58	3.00
3.00	3.20	3.00
3.00	3.43	3.00
2.90	3.00	3.00
3.00	**2.58**	3.00
3.00	3.09	3.06
3.00	3.43	**2.90**
2.93	3.27	3.01
0.13	0.34	0.05

ST = Styria; The lowest data are marked in bold and maximal values in bold red letter.

4.4.2. Animal health data by Federal Recording Association (LKV)

The summary of animal health problems is given to each farmer almost monthly by the LKV "daily report". The "daily reports" used in the present study originated from July and August 2020 when the survey took place. The treatments for metabolic, reproductive, udder, respiratory and musculoskeletal disorders were recorded within three months back from the day of milk testing. Farm ST-12 as the only one had no need for treatment for any cow within the past three months of recording in the available LKV "daily reports". Reproductive and respiratory diseases were excluded from the present study.

4.4.2.1. Metabolic disorders

An overview of hints about or even diagnosed cases cows that were suffering from metabolic diseases is given in table 13. Two farms lost one cow each within this time because of metabolic problems (ST-01 and 03). At seven farms, cows had to be treated because of metabolic disorders (ST-01, 03, 04, 09, 10, 13 and 16). The diagnosed diseases were hypocalcemia, azotemia and ketosis. At farm ST-01, 5.26 % of the cows per farm had to be treated because of symptoms of a metabolic disease. Cows with risk for ketosis were detected by the KetoMIR value that is an infrared measurement of the milk samples performed during the milk performance testing by LKV staff (Doherr et al. 2008, Werner et al. 2019). The average of cows per farm with risk for ketosis was 8.39 % (SD = 5.54). Early and late lactating cows had a higher risk for metabolic disorders due to the physiological adaptions and metabolic stress induced by high milk yield (Nielsen 1999). For early detection of metabolic disorders, their milk constituents were additionally evaluated by filtering abnormalities out. On average, 6.2 % of the cows per farm with DIM < 100 showed abnormalities in the milk constituents. The SD within this category was 3.99 %. 15.07 % was the mean of the late lactating cows per farm (DIM > 200) with abnormalities in the milk constituents with a SD of 10.09 %.

Tab. 13 Metabolic disorders (Hausegger and Auer 2014).

Farm code	**Drop out (%)**	**Treatment (%)**	**Cows with risk for ketosis measured and calculated by KetoMIR (%)**	**Abnormal milk constituents – DIM < 100 (%)**	**Abnormal milk constituents – DIM > 200 (%)**
ST-01	1.75	5.26	6.94	8.77	24.56
ST-02	**0.00**	**0.00**	25.35	4.00	10.00
ST-03	1.56	1.56	2.74	6.25	7.81
ST-04	**0.00**	1.41	3.80	**0.00**	8.45
ST-05	**0.00**	**0.00**	5.08	5.00	23.33
ST-06	**0.00**	**0.00**	7.29	5.00	8.33
ST-07	**0.00**	**0.00**	11.54	1.33	38.67
ST-08	**0.00**	**0.00**	**2.17**	5.00	21.25
ST-09	**0.00**	1.75	5.19	12.28	5.26
ST-10	**0.00**	1.79	9.88	10.71	10.71
ST-11	**0.00**	**0.00**	7.62	1.37	12.33
ST-12	**0.00**	**0.00**	8.00	8.33	**0.00**
ST-13	**0.00**	1.85	10.00	5.56	18.52
ST-14	**0.00**	**0.00**	12.07	13.95	11.63
ST-15	**0.00**	**0.00**	12.05	3.13	29.69
ST-16	**0.00**	2.13	4.55	8.51	10.64
Mean	0.21	0.98	8.39	6.20	15.07
SD	0.57	1.43	5.54	3.99	10.09

DIM = days in milk, KetoMIR = risk of ketosis from milk mean infrared (MIR) spectrum, ST = Styria; The lowest data are marked in bold and maximal values in bold red letter.

4.4.2.2. Claw and udder health

Cows with claw and limb disorders were detected in nine farms during the period of the past three months (Tab. 14). Two farms (ST-13 and 04) lost 1.85 % and 2.82 % of their cows due to claw and limb disorders. Claw and limb problems had to be treated at seven farms (ST-01, 02, 03, 09, 10, 11 and 16). The diagnosed diseases were claw related including claw and sole ulcer, white-line disease, double sole, bale horn rot, circumscribed sole hemorrhage and claw lesions caused by digital dermatitis (Mortellaro disease). From the available LKV data it could be concluded that four lactating herds were infected with the Mortellaro disease. The number of nine cows with claw lesions detected at farm ST-09 was the highest number by far among all farms.

During the same period udder problems were detected at nine farms (Tab. 14). A loss of cows because of udder problems was noted at four farms (ST-01, 03, 05 and 14), whereby farm ST-01 had the highest dropout quote with 5.25 % of cows. Udder treatment was necessary in six farms (ST-01, 04, 06, 09, 13 and 15), mainly indicated by acute mastitis. The highest percentage of udder treated cows was detected at farm ST-13 (11.11 %). All farms milked cows with a SCC > 200,000 cells/ml. A moderate mean percentage of 22.18 % lactating cows per farm was at risk to suffer from subclinical mastitis. The three parameters SCC > 200,000 cells/ml, marked increase of SCC and diagnosed udder disease were summarized into one udder health-related parameter resulting in an obvious higher mean of 27.08 % lactating cows.

Tab. 14 Claw and limb disorders and udder health.

	Claw and limb		Udder			
Farm code	**Drop out (%)**	**Treatment (%)**	**Drop out (%)**	**Treatment (%)**	**SCC > 200 (%)**	**SCC > 200 or marked increase of SCC or udder disease diagnosed (%)**
ST-01	**0.00**	1.75	5.25	7.02	21.05	29.82
ST-02	**0.00**	4.00	**0.00**	**0.00**	32.00	34.00
ST-03	**0.00**	9.38	3.13	**0.00**	**15.63**	23.44
ST-04	2.82	**0.00**	**0.00**	1.41	30.99	42.25
ST-05	**0.00**	**0.00**	1.67	**0.00**	21.67	25.00
ST-06	**0.00**	**0.00**	**0.00**	1.67	26.67	30.00
ST-07	**0.00**	**0.00**	**0.00**	**0.00**	16.00	**17.33**
ST-08	**0.00**	**0.00**	**0.00**	**0.00**	28.75	35.00
ST-09	**0.00**	15.79	**0.00**	1.75	15.79	19.30
ST-10	**0.00**	1.79	**0.00**	**0.00**	23.21	25.00
ST-11	**0.00**	1.37	**0.00**	**0.00**	20.55	21.92
ST-12	**0.00**	**0.00**	**0.00**	**0.00**	20.00	20.00
ST-13	1.85	**0.00**	**0.00**	11.11	20.37	31.48
ST-14	**0.00**	**0.00**	2.33	**0.00**	18.60	25.58
ST-15	**0.00**	**0.00**	**0.00**	1.56	26.56	29.69
ST-16	**0.00**	6.38	**0.00**	**0.00**	17.02	23.40
Mean	0.29	2.53	0.77	1.53	22.18	27.08
SD	0.82	4.47	1.55	3.11	5.36	6.60

SCC = somatic cell count (× 10³ cells/ml), ST = Styria.

The lowest data are marked in bold and maximal values in bold red letter.

4.4.2.3. Correlation between variables

There were two types of analysis to study correlations among variables: principal component analysis and regression analysis. The results of the principal component analysis are presented in figure 16, which assists in screening potential correlations between farm, diet and cow health variables (annex 5). The variables clustering closer to each other are more positively related than with those that are farther apart. Relationships of interest were circled in blue in the graph. Accordingly, DM content of PMR or forage (basalDM). The proportion of grass silage (Grass_silage) in the basal diet and the proportion of basal diet's particles on the largest sieve (Sieve1) were positively related. As shown in figure 17a, increasing the grass silage proportion in the basal diet increased the proportion of the largest feed particles (>°19°mm) of the diet. The middle section of the Penn State Particle Separator analysis (Sieve2 and Sieve3) was more closely related to the maize silage (Maize_silage) proportion in the basal diet. However, the relationship determined by regression analysis was not pursued because of the highly segregated values at the low and high inclusion of maize silage (data not shown). Further, the presumed risk of rumen acidosis based on the milk fat to protein ratio of < 1.0 (Acidosis) was also positively correlated to the maize silage proportion in the diet as well as the proportion of Holstein (HS) cows within the herd. Nevertheless, these correlations were not very strong as values were still not too close to each other.

There were other significant correlations that could be determined (Fig. 17b-d). Figure 17b shows that the content of the fine particle size section (< 1.18 mm fiber length) in the basal diet increased with increasing the NFC content ($p = 0.008$). With a weaker statistical significance ($p = 0.05$), the dietary concentrate in the total diet DM was positively related to milk yield (Fig. 17c). The percentage of forage in the total diet showed a linear relationship with the proportion of lactating cows with a SCC > 200,000 cells/ml ($p = 0.039$) (Fig. 17d). Accordingly, the more forage was fed in the diet the more lactating cows per farm had a raised SCC above 200,000 cells/ml. Interestingly, the content of NFC in the basal diet had a non-linear exponential relationship with the amount of claw and limb treatments ($p = 0.05$). According to the non-linear model, claw and limb treatments were drastically rising when the basal NFC was above 15 % (Fig. 17e). The cleanliness score of cows measured in the present work did not show significant correlations with the herd health problems recorded by LKV. Due to the different data characteristics, no correlations of interested variables with the quality and hygiene of the stored feeds can be adequately addressed with the correlation analyses performed herd.

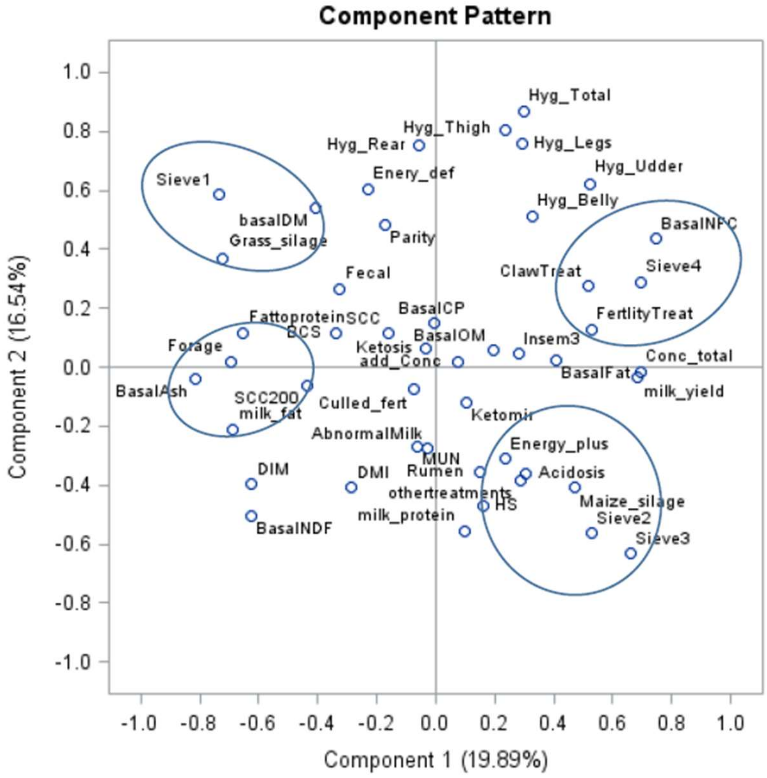

Fig. 16 The loading plot of principal component analysis showing the relationships among dietary, productivity and health variables (abbreviations are described in annex 5).

Blue circles indicate correlations of interest.

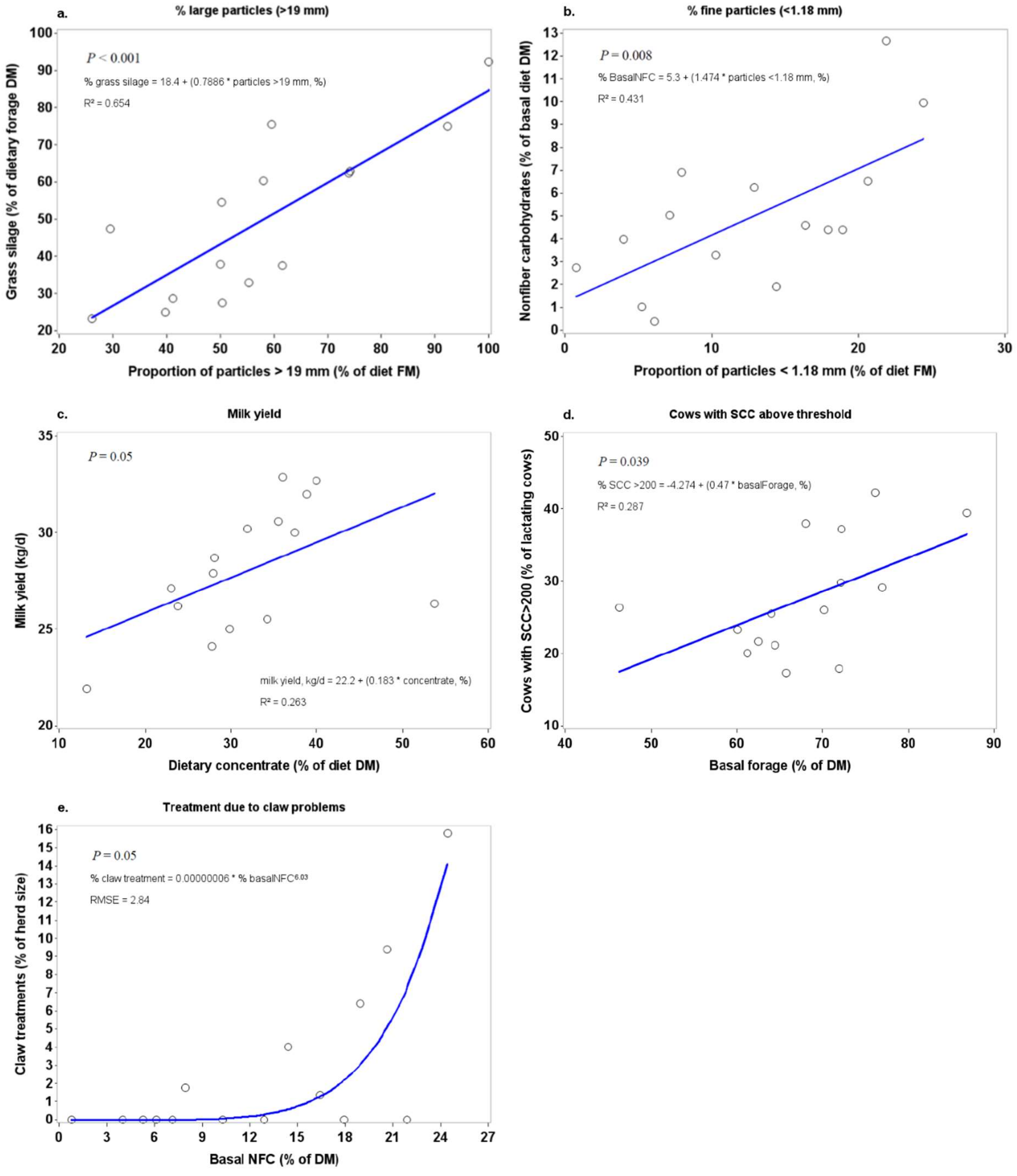

Fig. 17 Regression analyses of selected dietary factors and animal health parameters provided by LKV; p = p-value, DM = dry matter, FM = fresh matter, d = day, SCC = somatic cell count (× 10^3 cells/ml), NFC = non-fiber carbohydrates, RMSE = root mean square error.

5. Discussion

Animal nutrition is unfree of risk factors. Enabled by the dairy breed, high demands are expected from dairy rations to satisfy the metabolic need and productive output. During the periparturient and high-yielding period the dairy cow is faced with hormonal and metabolic challenges and nutrition-related diseases occur easily. The more these metabolic processes are understood by stakeholders the better rations can be composed to prevent dairy cows from these diseases. It has to be noted that dairy farms are operated to noticeable diversity in cow breed, farm size, composition of feeds, and feeding and barn management, among other factors, in addition to geographical and climatic differences. Understanding the real on-farm situation in a specific region is important to achieve the goal to understand the role of nutrition in satisfying productivity and acceptable animal welfare. In Austria, Styria was ranked thirdly after Lower and Upper Austria and centered in the province ranking milk production and herd sizes according to the LKV report in 2019. Furthermore, Styrian dairy farms are located in different topographic and climate condition affecting agricultural preconditions. In the south-east region of Austria like Styria, the precipitation decreases and dryness periods were enlarging over the years (Janke et al. 2015). Little quantity of forage feed sources leads to an increasing part of feed with bad nutritional quality and poor safety. Due to farms specialization (Poppe et al. 2007), the origin of feed had become diverse and with it the feed quality. Farms mostly produce their forage feed on their own and purchase the concentrates from national and international production facilities. Due to these factors, Styrian dairy farms are of particular interest. It was hypothesized that Styrian dairy farms use a variety of feed composition and feeding management which result in the different nutritional and hygienic quality of feeds among the farms and thereby affect productivity and health of the cows. The study aimed to assess whether there are production and metabolic problems developing due to deficient feed quality and hygiene in Styrian dairy farms.

5.1. Do Styrian farms differ in farm characteristics and feeding, and nutritional and hygienic status of diets?

The geographical distribution of the studied 16 Styrian farms was representative due to a previous study investigating the density of cattle per political district in Austria (Binder et al. 2019). The farms were located in valley ad hilly regions and not in high mountainous regions. In terms of attitude, the spread among farms was quite high with a range of 602 m above sea level. The organic farming system was present among surveyed Styrian farms, although the conventional system was dominant, which was similar to the national level report (BMLRT

Abteilung II 1 2020). Due to the selection criteria, the size of the studied farms was above the Styrian average of 24 cows per farm reported earlier (Kalcher et al. 2020). In the present study, the average number of lactating cows per farm of 50.4 (SD = 9.96) was more than twice as high as the Austrian average of 18.7 dairy cows per farm (Kalcher et al. 2020). Even though larger farms tend to be more standardized in feeding and management, they still differed.

According to the feeding system classification by FAO factsheets, 15 farms could be allocated to the year-round silage system and only farm ST-10, which used a high amount of grazing throughout the year, to the green fodder plus silage system. The "haymilk" system was not present among the study farms (FAO et al. 2014).

As expected, besides the feeding system, the composition of feeds, ingredient composition, nutrient composition and particle size of basal diets showed a high diversity among farms. Although the Styrian farms fed high-forage diets (above 88 % in all farms), forage feed types and the amounts included in the ration differed greatly among farms. The use of grass silage was ubiquitous, but with a wide range of 26-100 % of basal diet. Maize silage was included in three-quarters of the studied farms to a smaller among ranging from 4-44 % basal diet, always in addition to grass silage. This was expected since maize silage is usually added to boost the energy intake for producing cows (Steinwidder 2000). On average, the surveyed Styrian farms even used a higher percentage of grass silage (60 %) in the total diet, compared to the study of Steinwidder (2000) with an Austria-wide value of 49.2 % of grass silage in farms without the use of maize silage in winter-feeding rations. According to Steinwidder (2000), an average amount of 17 % of maize silage was included in the diet in the winter-feeding period, always in addition to grass silage (50.4 %). Overall, hay was used the main forage source in the 45 surveyed farms of Steinwidder (2000), which was different from the current study.

In addition to the two common silages, the brewery's spent grain was another major feed ingredient in the basal diet in the present study. It was included in about one third of the farms, but often used below 10 % of basal diet. An increasing number of farmers uses the brewery's spent grain, as a protein dietary source to improve the amount of milk yield and milk constituents because of the advice of several current studies (Ikram et al. 2017, Muthusamy 2014, Westendorf and Wohlt 2002). Other forage ingredients were parts of basal rations. Straw was used in small amounts in half of the farms. Straw in the ration helps to reduce energy density because of its low content of nutrients and maintain dietary fiber contents especially of cellulose and so improves the rumination process. Furthermore, it dries out diets with a lot of wet ingredients and makes the ration more acceptable to the cows (Anderson and Hoffman 2006, Kamphues et al. 2014, Shaver and Hoffman 2010). The farm ST-02 included 17.4 % of an additional silage mix containing peas, sunflowers, clover, and rye whole plant and 13 % hay possibly to compensate the reduced use of grass silage (26 %) relative to maize silage (34.8 %) in the basal diet.

Besides the proportion of forage, the particle size is also relevant in terms of ruminant adequacy (Zebeli et al. 2010). Due to the differences in silage types and their inclusion levels, the particle distribution of the basal diets also highly differed among the Styrian farms. The long fiber section (> 19 mm fiber length) especially had the widest range among the farms with the values from 23 to 96 %. As shown by the correlation analysis, this could be explained by the wide range of the proportion of grass silage in the diet. This suggests that grass silage is preferred over maize silage because of its longer particle size (Kamphues et al. 2014) that is known to increase chewing activity and so better regulates the rumen pH, and improves a healthy and productive microbial activity in the forestomach system (Brandstetter et al. 2019, Grant and Ferraretto 2018, Kröger et al. 2019). The smaller particles (8-19 mm and 1.18-8 mm) showed smaller variations about 19 ± 12 % and 24 ± 12 % (mean ± SD), respectively, and the fine particle portion (< 1.18 %) showed the least variation among farms about 4.6 ± 3.3 %. Compared to expert recommendations of particle size sections in TMRs (> 19 mm: 3-8 %; 8-19 mm: 30-40 %; 1.18-8 mm: 30-40; < 1.18 mm: < 20 %) (Kamphues et al. 2014), the long fiber length section was hugely overrepresented and the fine fiber section was underrepresented in the diets of the study farms. The middle sieve sections (8-19 mm and 1.18-8 mm) were also underrepresented, but less strong. It is noted that TMR includes the full ration of concentrates additionally to the forage (Kamphues et al. 2014), the particle size sections determined here were of the PMRs or forages and a portion of concentrate fed separately was not accounted for. Concentrate consists mostly of cereal grains, legumes, by-products, vitamins and mineral feed (Kamphues et al. 2014) that contribute to fine particle fraction of the Penn State Particle Separator. This fine particle was correlated with the NFC percentage in the basal diet. Therefore, underrepresented fine particle portions and overrepresented large particle portions than what recommended for TMR are not surprising.

The proportions of the main nutrients in the diet showed quite a big variety, *inter alia*. In line with the high forage inclusion level, the NDF results (50-70.9 % DM) suggest adequate rations for ruminants are used in Styrian farms. In terms of metabolic health, the literature requires a minimum of 25-32 % $peNDF_{>1.18}$ in the ration depending on the values of NFC (Kamphues et al. 2014, Zebeli and Humer 2016). In line with the relatively low and the fine particle portion (< 1.18 %), the NFC of the basal rations were also low and ranged between 0.8 and 24.4 % DM. The additional concentrate intake accounted for small proportions (11.5-27.4 % of total estimated DMI). For instance, the farm ST-09 showing the maximum NFC of basal diet included additional concentrate at 15.8 % of total DMI. These values suggest that the NFC contents of total diets in these farms were likely lower compared to the expert recommendations of 36-44 % DM absolute maximum level (NRC 2001). Further, the average CP of 15.5 % DM (SD = 1.3 % DM) in the basal diets already corresponded quite well with the recommended value of 15.2 % DM for HF cows with 35 kg milk yield per day (NRC 2001). This was likely explained by the use of large proportions of grass silage (mean ± SD = 60 ± 22%) that has a CP content almost twice as high as maize silage (grass silage (wilted) = 56 g/kg OM and maize silage (end of dough maturity) = 27 g/kg OM) (Kamphues et al. 2014). Additionally, 44 % of the farms fed protein-concentrated feed within the basal ration. The interpretation of the farms' values with reference values needed to be handled with care because of the difference between TMR and PMR. Nevertheless, the NDF and NFC results proved that Styrian dairy farms produce under low economical pressure compared to countries with more intensive farming structures, e. g. the USA.

Based on the sensory evaluation, overall, the feed quality was "satisfying" or above. The assessment with the term "very good to good quality" was given for grass silage at 19 % of the farms and for maize silage at 42 % of the farms. Deficiencies were detected in terms of hygienic status of silages with only about the half of all evaluated silages had a proper hygienic status. Both silage types were of proper hygienic status at 6 farms, where by one farm only used grass silage. Grass silages were assessed proper at 50 % of the farms and the remaining farms used grass silage with vast to minor deficient hygienic status. 58 % of the on-farm stored maize silages were of proper hygiene and 42 % of them had minor deficiencies. For most farms, other silages and concentrates presented mostly proper hygienic status. The macroscopical occurrence of mold was few and mainly located on the very top layer of the bunker silo immediate under the tarpaulin. This was expected as the aerobic milieu at the top of the cut surface favors fungal growth and mycotoxin contamination (Kamphues et al. 2014). Furthermore, the sampling was performed in the summer and surface location is predisposed for heat development. These current results also are in line with an evaluation of questionnaires among Austrian dairy farmers (Resch 2017) that reported up to 64 % of the interviewed farmers had problems with the occurrence of superficial mold in maize silage in

2012. Resch (2017) assumed annual fluctuations depending on the infectious pressure of mycotoxigenic fungi. In the current study, almost two-thirds of the farms used the sandwich method of silages at storage. There was no available literature about the establishment of sandwich silage and its effects on feed hygiene and quality as compared to typical ensiling system. According to an agricultural online newspaper report (Pflaum 2014), it was assumed by the author that the sandwich method was used for practical reasons. It would allow proper ensiling, an increased feed rate and thereby decreased the time of exposition to oxygen, reducing spoilage (Pflaum 2014) and associated risks to hygienic deficiency.

5.2. Do Styrian farms differ in animal productivity and health, and which part of the feeding and nutrition could explain the poor productivity and health in Styrian farms?

Based on the on-farm evaluation, body condition score and rumen and fecal scores as well as cleanliness score of lactating cows showed no high variations among the surveyed Styrian farms. The average body condition scores of the herds of 3.25 (SD = 0.34) were within physiological ranges only showing slight differences according to the main breed of the farm.

Overall study farms, the proportions of the dairy breeds at the time of survey were similarly distributed like the proportions across whole Austria (values provided by the current annual report LKV and written in brackets in the following sentence). Accordingly, the Styrian main dairy breed was the FV breed with a percentage of 69 % (74.1 %) followed by 19 % HF (12.2 %) and 6 % BS (10.3 %). The annual report 2019 by LKV included a further 3.4 % of other breeds (Kalcher et al. 2020). In the present study, only one of the 16 studied farms had a herd of lactating cows with equal shares of HF and BS. With respect to the average milk yield, comparability of the current study was ensured when put in context with the annual data of Austria. The Austria-wide value was only available in the unit per full lactation (LKV Austria 2021a). Therefore, the following calculation was done by the author with the value in 2020: 7896/305 = 25.89 kg milk/d/cow using 305 days as the standard lactation period (LKV Austria 2021d). The average milk yield of 27.66 kg milk/d/cow of the Styrian study farms was slightly above the Styria-wide value of 26.03 kg milk/d/cow and higher than the Austria-wide value estimated above (LKV Austria 2021c). The higher average milk yield among the studied farms could be explained by their large herd sizes about 50.4 (SD = 9.96) lactating cows per farm. This average herd size was almost twice the Austrian average number of 18.7 cows per dairy farm (Kalcher et al. 2020). Farms with bigger herd sizes were the result of modernization and intensification of the dairy industry. It led to more intensive feeding, genetic selection and management practices and further to higher milk production (Egger-Danner et al. 2020). Still, as part of the project D4Dairy with the selection criteria to include farms with 50 lactating cows or more, initially these Styrian farms generally held a larger herd size. Apparently, herd sizes of these farms fluctuated over the years. In 2020, these Styrian farms held a range of 37 to 71 lactating cows per farm. This shows that not all farms have moved forwards larger farm size.

To emphasize the diversity, the two organic farms had particularities in terms of milk yield, forage feed, feed quality and hygiene, the types of breeds and the herd size. According the organic farming system, farming limits are the allowed feeds because of the ecological farming conditions and therefore more restrictive agricultural framework (BMSGPK 2021). However, financial compensation is provided. According to the annual price report of dairy products, organic farms earned about 10 cents (= about a quarter) more per kg milk compared to conventionally produced milk (Griesmayr and Leutner Oktober 2020). Regarding the productive performance of the two farms, the lowest average milk yield was detected. The values were 21.5 kg milk/d/cow and 21.9 kg milk/d/cow (ST-10 and 12). From the dietary perspective, this was caused by the high amount of forage feed in the diet usually containing lower energy density compared to concentrate with cereal grains and oilseeds (Kamphues et al. 2014). The farm ST-10 used a lot of grazing. However, the amount of grazing intake was not quantitatively estimated in the present study. Consequently, the estimated intake of the basal diet was very low. Due to this fact and other reasons, the data of feed intake of this farm could not be used in the study. Farm ST-12 used 100 % grass silage in the forage and the amount of concentrate was the lowest among all farms (13 % DM). Regarding feed quality and hygiene, the grass silage, that was used besides grazing, was only of satisfying quality and significant deficient hygiene at the two organic farms. So, the farmers could have been used forage feed of higher quality and more optimal hygiene to push productivity. Both farms used the dual-purpose breed Austrian FV only and they had the lowest number of lactating cows, 43 cows at farm ST-10 and 37 cows at farm ST-12.

Besides the organic farming system as a cause of low farm productivity, some conventional farms showed poor performance. Low levels of feed hygiene were observed at three conventional farms (ST-05, 08 and 11) with an average milk production below (25; 24.1; 26.3 kg milk/d/cow) the study farm average of 27.66 kg milk/d/cow using grass silage of minor (ST-05) or even vast deficient hygiene (ST-08). Farm ST-11 used maize silage of minor deficient hygiene in combination with minor hygienic deficient grass silage. Regarding poor productivity, the high average cleanliness score of farm ST-13 did not have any effect on feed hygiene and productivity, although the percentage of lactating cows suffering from subclinical or clinical mastitis was quite high on this farm (31.5 % of the lactating cows). Another farm characteristic factor was the selection of breeds indicating insufficient use of genetic potential. The productivity (25.5°kg milk/d/cow) was even below the overall farm average milk yield in one farm (ST-07) with main HF breed herds and therefore not following the higher average milk yield per cow expected due to Styrian LKV course statistics saying that the HF breed has constant higher milk yield that FV and BS (LKV Steiermark 2020c). Restrictively, it has to be said that the herd average DIM in this farm was the second highest (249 days) among the farms. However, this example shows very well, what an impact farm management has on productivity. In addition to that, among factors investigated the composition of feeds, which affected the nutrient composition and particle size, played a bigger role in affecting claw, limb and udder health.

In relationship with the dietary concentrate, the milk yield significantly more elevated with higher proportions of concentrate. This relationship revealed the classification of the farms into two groups, one group with relatively higher milk yield (ST-02, 05, 07, 08, 11, 12) and the other group (ST-01, 03, 04, 06, 09, 13, 14, 15, 16) that shows a lower milk yield. Both groups had a positive relationship between the proportion of concentrate feed in the diet DM and the milk yield and obviously other factors beyond the dietary level of concentrate influence the milk yield potential. The group with a milk yield of 26.3 kg milk/d/cow or lower included the farm performing organic (ST-12) and thus, extensive farming conditions that used a relatively low concentrate level (13.2 % of total diet DM). The feed intake level could also play a role because the supplementation of concentrate pushes the milk yield, however, it needs to be used wisely not to trigger SARA. This could be proved by farm ST-13, representing the high producing group of farms (27.1 kg milk/d/cow and more), that fed a relatively high proportion of concentrates (40 % of total diet DM) in the ration and reached the relatively high milk yield of 32.7 kg/d/cow.

Health problems, extracted from the LKV “daily report”, were actually based on a three month period and o the period of one year for KetoMIR. There was no clear pattern for good or bad farms and health problems detected were unique in each farm. In the Styrian farms, clinically detected metabolic disorders played a subordinate role. The necessity of treatment for metabolic disorders was present in 43.75 % of the farms, although the cases per farm were low ranging from 1.4 to 5.3 %. The maximum value was detected at farm ST-01. One explanation for this result could be that this farm had the highest value of total DM intake (27.4 kg DM/d) and the proportion of concentrates in the total feed DM (36 % DM) was above the average value of all studied farms (32.1 %) and equaled the recommended maximum limits of NFC of 36-44 % for TMRs (NRC 2001). High NFC content in combination with low NDF in the diet indicates the risk for the cows to suffer from (subacute) rumen acidosis because high levels of carbohydrates lead to a pH drop in the rumen that destroys healthy bacteria species of the ruminal microbiota when the buffer capacity is insufficient. This pathophysiological scenario should be avoided to improve animal health and productivity (Krause and Oetzel 2006). Moreover, in terms of feed hygiene, farm ST-01 used grass silage with a significant hygienic deficiency in an average proportion of 41.15 % in the PMR. Common diagnoses of metabolic disorders in these farms were hypocalcemia and azotemia/ketosis. Additionally, a potential risk for ketosis was given by the KetoMIR parameter, showing a quite wide range from 2.2 to 25.4 % of lactating cows per herd that were under special risk to suffer from ketosis. The maximum value of 25.4 % of lactating cows per herd was detected at farm ST-02. Usually, this is caused by deficiencies in the diet for cows during the transition period and/or a slightly below the average value of total DM intake per cow per day (Doherr et al. 2008, Werner et al. 2019). The problem tent to appear for some individual cows. But it was impossible to acquire the feed intake data of individual cows in the current study. All silages used in the diet of farm ST-02 were of at least satisfying quality and of proper hygiene. So, a direct cause could not be found with the available data.

Cases of subclinical mastitis detected by the SCC > 200,000 cells/ml were present in all studied dairy cattle herds. The median (± SD) of 20.8 % (± 5.4) of lactating cows per herd with a SCC > 200,000 cells/ml was quite low when compared with the value of a current European study (Krieger et al. 2017). The mentioned study investigated the prevalence of so-called production diseases related indicators at 192 organic dairy farms in Germany, Spain, France and Sweden (Krieger et al. 2017), but likely because they defined by a SCC > 100,000 cells/ml and so the median prevalence (interquartile range) of subclinical mastitis was detected with a higher median of 51.3 % (SD = 15.4 %) than the current value. To the author’s knowledge, no comparable data have been reported, where subclinical mastitis was defined by a SCC > 200,000 cells/ml. Still, a median prevalence of 20.8 % is alarming in terms of animal welfare issues. An interesting result of the present study was the weak significant relationship between the proportion of basal forage in the diet and the prevalence of cows with an SCC > 200,000 cells/ml. It has to be mentioned that additional concentrate feed was not included in the basal forage. A possible explanation of this positive relationship can be speculated that due to low energy levels in the diets of high performing cows, causing a marked negative energetic balance with associated reduction of the immune competence, making the herds more susceptible to infections such as mastitis (Ingvartsen and Moyes 2013). A further cause of immune system depression are mycotoxins (Devegowda and Ravikiran 2009, Fink-Gremmels 2008b). Some reports have indicated a link between mycotoxins in diets and udder health problems (Fink-Gremmels 2008b, Santos and Fink-Gremmels 2014). Silages are a major source of mycotoxins in dairy diets, especially maize silage (Dänicke et al. 2020). 44 % of the investigated farms also used maize silage that indicated special risk for mycotoxin contamination for the diets of these farms. However, the influence of ensiling management should not be underestimated. A review emphasized that poor post-harvest management especially favors spoilage growth, while acidity and reduced oxygen conditions do not favor it (Alonso et al. 2013). However, there could not be found any significant relationship between metabolic disorder prevalence and nutritional or hygienic parameters assessed on farm. But this does not rule out mycotoxin contamination of rations.

While studies have repeated showed that high-grain (starch) feeding induces acidosis (Krause and Oetzel 2006, Lean et al. 2013). In the present study, no strong relationship between targeted nutritional factors and acidosis, diagnosed based on milk variables, was detected. This is not uncommon because the diagnosis of acidosis based on milk parameters is not sensitive and specific enough and a combination of several diagnostic tools for the detection of SARA would be advised by the literature (Humer, Aschenbach et al. 2018).

A remarkable result obtained the current data was the significant correlation between the claw and limb disorder treatment and the amount of basal NFC in the diet. The basal NFC cut off value of 15 % DM indicates that the proportion of claw and limb disorder treatment increased exponentially. The clinically diagnosed claw and limb disorders reached a level of 15 % at farm ST-09 where 24.4 % DM basal NFC was fed in the PMR. A review study (Lean et al. 2013) evaluated the co-occurrence of lameness and rumen acidosis, triggered by high amounts of NFC in the diet. Starch is the most abundant component in NFC fraction in typical dairy rations and is elevated when including more cereal grain, while water soluble carbohydrates like oligosaccharides increase the share when dominated in the NFC fraction (NRC 2001). At high amounts, these NFC can be problematic for rumen health causing disorders such as acidosis and lameness, but starch is more potent. There was also evidence that laminitis is caused by ruminal histamine, endotoxin and lactate production, all of which are elevated by increase dietary NFC contents (Lean et al. 2013). According to the same review, investigating interactions between lameness and rumen acidosis in relation to the dietary NFC amount stays challenging because of unclear definitions of these diseases. Besides increasing NFC, the literature stated that an unphysiological low feeding frequency and amounts can cause high incidences of claw lesions (Bergsten 2003). Other than that, at this specific farm, the feeding frequency was by far the highest with a value of five times a day.

It must be underlined that lameness is only part of the claw treatment on farm and thus, the correlation observed here could be coincidental. Still, the present evidence and sportive evidence from the collective results reported by Lean et al. (2013) highlight the consideration of diet as part of treatment and prevention of claw and metabolic problems.

Completing the discussion, the limitations of the present study should be mentioned. As a result of selection criteria of the D4Dairy project and the willingness to participate by chosen farms, the sample size of 16 farms was relatively small and these farms hold a relatively large herd size than the Styrian average. With that, farms with high technical advancement (e. g. milking robot) were included in the study. Therefore, the results and interpretation here cannot entirely represent the entire Styrian scenarios. In terms of sampling and LKV data, only spot data could be carried out that might limit the significance of conclusion on health variables because one cannot assume precisely when a health problem could appear after prolonged nutrition problems. However, the data were valid for studying milk production data because milk yield and composition change instantly in response to the intake of nutrients. The statements resulting from the regression analysis are also limited because of the low R^2 values that was explained by the low sample size of this study. Still, cross-linking between nutritional and animal health parameters were explored and it was able to show that claw and limb problems are associated with NFC contents, and dietary forage proportion with udder health, which can be backed up by biologicals reasons underlining an importance of feeding and nutrition.

6. Conclusion

The composition of feeds turned out to be the most diverse management factor compared to farm characteristics and feed hygiene in Styrian dairy farms. As a result, nutrient composition and particle size distribution were also largely diverse among the farms. Farms also showed varied productivity and health status, although “poor health” or “good health” were not apparent as farms showed unique prevalence of metabolic and udder health diseases. Still, certain relationships between dietary factors and milk yield, udder health or claw and limb health can be proven. Accordingly, dietary forage was related to the percentage of lactating cows in the herd with measured SCC > 200,000 cells/ml, indicating subclinical mastitis. The significant relationship between the basal NFC proportion in the diet and the percentage of claw and limb treatment per herd was remarkable, expressed by a positive exponential curve. These findings indicate an importance of diet and feeding on productivity and health of dairy cows. Certain dietary factors like forage feed types and the amounts of forage and concentrate fed to cows should be monitored with care at the farms especially when facing udder and claw and limb problems. Improvement of animal herd health and productivity through reducing nutritional risk factors is possible.

7. Summary

Farm and feeding management have an impact on animal health and productivity and bad management can lead to economic losses. However, on-farm data of feed quality, nutrition and hygiene are rare. Styrian dairy farms are of interest because of relatively smaller farm sizes in hilly and mountainous areas. Therefore, substantial diversity regarding the composition of feeds, and feeding and farm management is expected. Data collection included farm visits of 16 Styrian dairy farms in summer 2020 and feed analytic methods of the taken samples at the laboratory. Feed samples of PMR, forage and concentrates were collected on-farm as well as sensory evaluation of on-farm stored silage sources and a face-to-face survey with the farmer were performed to collect data related to the three farm management pillars: farm characteristics, feed hygiene and composition of feeds. A set of the lactating cows proportional to the herd size were scored in terms of rumen, fecal, body condition and cleanliness. In the laboratory, the sampled PMR/forage sample was used for the particle size determination and nutrient (proximate) analysis. Productive and health data was extracted from the LKV "daily" report. Correlations were performed between targeted nutritional characteristics and animal health parameters. All in all, the composition of feeds turned out to be the most diverse farm management factor. Different proportions and types of single silage and the concentrate feed led to a big variation of the nutrient composition and particle size of the basal diet. As indicated from regression analysis, the percentage of lactating cows in the herd with measured SCC > 200,000 cells/ml increased with increasing proportion of forage in the basal diet. There was a remarkable increase of the percentage of claw and limb treatment per herd when the basal NFC proportion in the diet was exceeding 15 %. Based on these findings, ration composition and feeding management have an essential impact on animal health and performance of dairy cows. Consequently, careful monitoring of forage and concentrate amounts is required to improve the prevalence of production-related diseases, such as udder and claw and limb problems.

8. Zusammenfassung

Suboptimales Betriebs- und Fütterungsmanagement wirkt sich negativ auf die Gesundheit und Produktivität von Milchkühen aus, was zu wirtschaftlichen Verlusten führt. Wenige betriebsspezifische Daten über Futterqualität, Rationsgestaltung und hygienische Aspekte sind jedoch bekannt. Steirische Milchviehbetriebe sind von Interesse, da sie relativ kleine Betriebsgrößen aufweisen und sich in Hügel- und Berggebieten befinden. Daher ist eine große Vielfalt bei der Futterauswahl und des Fütterung- und Betriebsmanagements zu erwarten. Die Datenerhebung umfasste Betriebsbesuche in 16 steirischen Milchviehbetrieben im Sommer 2020 und futtermittelanalytische Methoden der entnommenen Proben im Labor. Je nach Verfügbarkeit wurden Futterproben von partiell gemischten bzw. aufgewerteten Grundrationen sowie Grund- und Kraftfutter direkt vom Futtertisch entnommen sowie eine sensorische Bewertung der auf dem Betrieb gelagerten Silagearten und eine persönliche Befragung des Landwirts durchgeführt, um zu folgenden drei Säulen des Betriebsmanagements Daten zu generieren: Betriebsspezifische Merkmale, Futterhygiene und Futterauswahl. Bei einer Gruppe von laktierenden Kühen, deren Größe in Relation zur Herdegröße bestimmt wurde, wurden die Pansenfüllung, die Kotkonsistenz, der Ernährungszustand und die Sauberkeit beurteilt. Im Labor wurden die Proben von Grundration bzw. Grundfutter für die Partikelgrößenanalyse mittels Schüttelbox und die Weender-Analyse verwendet. Produktivitäts- und Gesundheitsdaten wurden den betriebsspezifisch erstellten Tagesberichten des LKV entnommen. Signifikante Zusammenhänge wurden zwischen gezielten fütterungsbezogenen Merkmalen und Tiergesundheitsparametern hergestellt. Insgesamt erwies sich die Auswahl der Grundfutterkomponenten als der am unterschiedlichsten ausgeprägte Betriebsmanagementfaktor. Unterschiedliche Mengenanteile der einzelnen Silagearten und des Kraftfutters führten zu einer großen Bandbreite an Nährstoffzusammensetzungen. Die Regressionsanalyse zeigte an, dass der Anteil an laktierenden Kühen in der Herde mit einer Zellzahl von mehr als 200.000 Zellen/ml anstieg, je höher der Anteil an Raufutter in der Grundration bzw. im Grundfutter war. Weiters war ein markanter Anstieg des Anteils der Kühe in der Herde mit behandelten Erkrankungen an Klauen- und Gliedmaßen zu erkennen, wenn der Anteil an NFC in der Grundration bzw. dem Grundfutter 15 % überschritt. Die Untersuchungen zeigte, welch großen Einfluss die Zusammensetzung der Ration und das Fütterungsmanagement auf Leistung und Tiergesundheit haben. Es ist anzuraten, dass Grundfutter- und Kraftfuttermengen kontinuierlich überwacht werden, um Krankheitsprävalenzen im Bereich der Eutergesundheit und der Klauenerkrankungen bestmöglich verbessern zu können.

9. List of abbreviations

BCS	Body condition score
BMG/F	Austrian Federal Ministry of Health (and Women) (in German: Bundesministerium für Gesundheit (und Frauen))
BMLRT	Austrian Federal Ministry of Sustainability, Tourism and Regions (in German: Bundesministerium für Landwirtschaft, Regionen und Tourismus)
BMSGPK	Austrian Federal Ministry of Social Affairs, Health, Care and Consumer Protection (in German: Bundesministerium für Soziales, Gesundheit, Pflege und Konstumentenschutz)
BS	Brown Swiss
BW	Body weight
CF	Crude fat
CP	Crude protein
DCAD	Dietary cation-anion difference
DIM	Days in milk
DM/DMI	Dry matter/Dry matter intake
FM	Fresh matter
FS	Fecal score
FV	Simmental (Austrian: Fleckvieh)
GLM	Generalized Linear Model
HF/HS	Holstein Frisian
KetoMIR	Risk of ketosis from milk mean infrared spectrum
LKV	Landeskontrollverband
Mg	Magnesium
NE(P)B	Negative energy (and protein) balance

NEL	Net energy of lactation
NEFA	Non-esterified fatty acid
NFC	Non-fiber carbohydrates
NLIN	Non-linear regression model
NRC	National Research Council
NUTS	Nomenclature of territorial units for statistics
peNDF	Physically effective neutral detergent fiber
PMR	Partial mixed ration
PRINCOMP	Principal component analysis
Proc	Procedure
RS	Rumen score
SARA	Subacute rumen acidosis
SCC	Somatic cell count
SD	Standard deviation
TMR	Total mixed ration
ZAR	Association of Austrian Cattle Breeders (in German: Zentrale Arbeitsgemeinschaft österreichischer Rinderzüchter)

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11. List of Figures

12. List of Tables

Annex 1

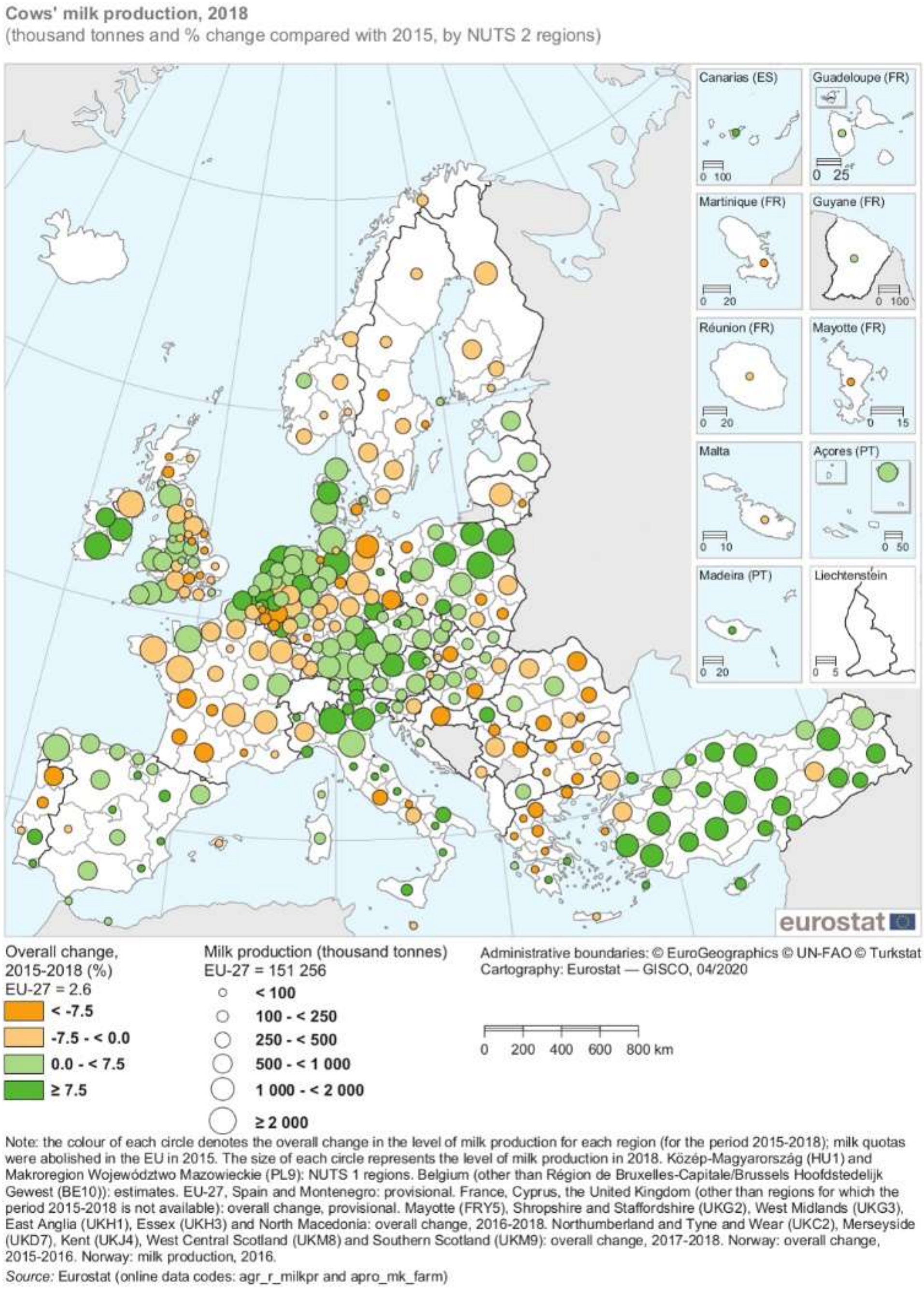
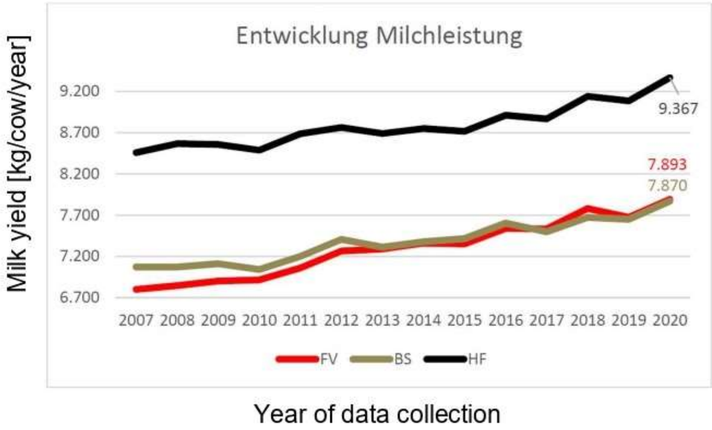
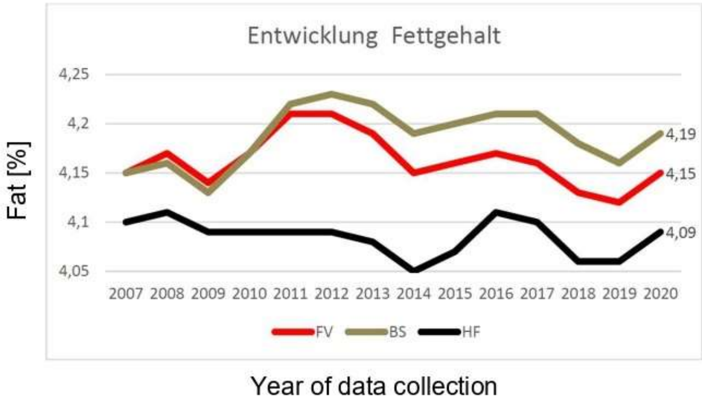


Fig. 18 Development of cows' milk production from 2015-2018 in Europe (Eurostat 2020); NUTS: nomenclature of territorial units for statistics (Eurostat 2004).

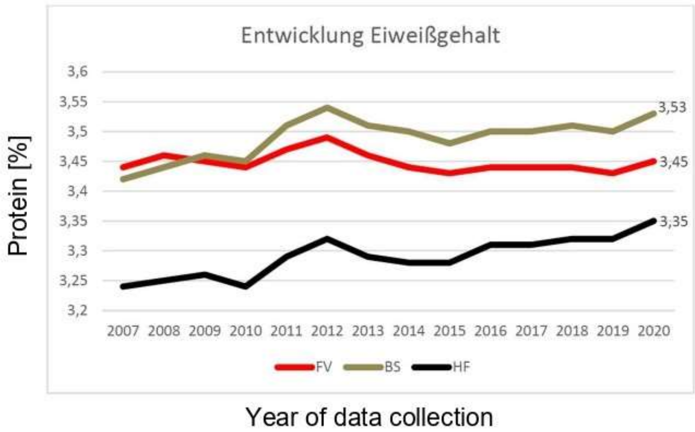
Annex 2



a. Milk yield



b. Fat



c. Protein

Fig. 19 Development of milk yield and milk compounds per main dairy breed in Styria over the last ten years (LKV Steiermark 2020c); FV = Simmental (Austrian: Fleckvieh), BS = Brown Swiss, HF = Holstein Frisian.

Annex 3

LKV sample "daily report" (LKV Austria 2020)

TAGESBERICHT mit QS-Kuh

LKV

Burgenländischer Rinderzuchtverband
7400 Oberwart, Industriestrasse 10
rinderzuchtverband@lk-bgld.at, www.lkv.at
T: 03352/325 12

Testhofer
Bach Bruno
Ort 1234
1234 Testdorf

Ergebnis **19.02.2019** 17:00
Kontrollintervall: 38 Tage AT5
LFBIS-Nr 2526
Druckdatum: 26.04.2019 Liste 204
E-Mail: testbauer@test.cc

Ergebnis der Probemelkung

Nr.	Name	Lebensnummer	L.	Tg.	v_Mkg	M-kg	Fett%	Eiw%	Zellz.	FEQ	Harn.	Kl
	ZENTA	AT 571.466.719	5	45	42,8	37,4	4,08	2,84 -	41	1,44	1 -	1
	MELLA	AT 971.750.119	4	160	32,2	29,2	3,96	3,31	296 !	1,20	0 -	4
	PIKE	AT 353.085.822	4	144	35,2	31,2	3,95	3,50	259 !	1,13	3 -	4
	SULI	AT 688.120.222	3	148	36,4	34,4	4,36	3,17 -	163	1,38	13 -	1
	WOLLE	AT 688.121.322	3	215	29,8	trocken						
	SOLI	AT 688.123.522	3	197	33,0	29,4	5,05	3,47	144	1,46	4 -	4
	ZONE	AT 201.580.328	3	321	38,6	32,6	4,39	4,02 +	2243 !	1,09	0 -	7
	BIRGIT	AT 891.719.622	3	55	44,8	40,8	3,87	2,73 -	136	1,42	4 -	1
	ANNE	AT 201.577.828	2	351	26,8	trocken						
	GINA	AT 460.761.128	2	321	25,0	23,0	4,69	3,74	171	1,25	0 -	4
	BABSI	AT 455.732.528	2	84	37,0	34,4	4,76	3,10 -	13	1,54 +	4 -	1
	PAUKE	AT 019.286.229	1	560	T	trocken						
	SOLA	AT 818.230.929	1	321	19,2	trocken						
	MARA	AT 494.063.829	1	258	14,8	14,2	6,23	4,10 +	76	1,52 +	2 -	7
	ZITA	AT 818.234.429	1	95	38,4	33,6	4,87	3,12 -	68	1,56 +	5 -	1
	BABSI	AT 818.238.829	1	67	36,4	31,2	4,28	2,98 -	25	1,44	0 -	1
	BERLI	AT 318.170.738	1	84	26,2	24,8	3,88	2,85 -	24	1,36	4 -	1
17 Kühe, in Milch 13		**Su. 396,2 kg**	**2,4**	**202**	**32,3**	**30,5**	**4,40**	**3,24**	**292**	**1,36**	**3**	
+0 Kühe, in Milch -3		Su. -120,4 kg				-1,8	+0,58	-0,09	+150	0,21	+0	

Gleitender Stalldurchschnitt

	Tage	Kuhanzahl	M-kg	F-%	F-kg	E-%	E-kg	F+Ekg
letzte 12 Monate	**365**	**15,9**	**9.150**	**4,22**	**386**	**3,39**	**310**	**696**
2018	365	16,2	8.681	4,37	380	3,50	303	683

1070 2526 V 4.00

Blatt 1 von 6 26.04.19

Wichtige Hinweise zum Herdenmanagement von 19.11.18 bis 19.02.19

Eutergesundheit

18% der Kühe (das sind 3 Kühe) weisen bei der aktuellen Kontrolle eine Zellzahl über 200.000 auf

Fütterung und Stoffwechsel

6 frischmelkende Kühe sind auf Grund der Inhaltsstoffe auffällig

2 altmelkende Kühe sind auf Grund der Inhaltsstoffe auffällig

Fruchtbarkeit

2 Kühe wegen Fruchtbarkeitsproblemen abgegangen

7 Kühe (41%) (zwischen 29. und 150.Laktationstag) noch nicht besamt oder Besamung noch nicht gemeldet

Weitere Informationen

1 Kuh wegen "Hohes Alter" abgegangen

Eutergesundheit

Kühe mit ZZ > 200.000 oder mit markantem Zellzahlanstieg oder mit Diagnosen (Schalmtest empfohlen)

Nr.	Name	Lebensnummer	L.	Tg.	19.02.19 Zellzahl	12.01.19 Zellzahl	03.12.18 Zellzahl
	ZONE	AT 201.580.328	3	321	2243	384	368
	MELLA	AT 971.750.119	4	160	296	178	361
	PIKE	AT 353.085.822	4	144	259	211	479
	GINA	AT 460.761.128	2	321	171	79	171
	SULI	AT 688.120.222	3	148	163	57	6
	BIRGIT	AT 891.719.622	3	55	136	30	T

Fütterung und Stoffwechsel

Milchinhaltsstoffe nach Klassen

Klasseneinteilung	Kühe	M-kg	Fett%	Eiw%	Zellz.	FEQ	Harn.
1 - 15,0 kg	1	14,2	6,23	4,10	76	1,52	2
15,1 - 25,0 kg	2	23,9	4,29	3,30	98	1,30	2
25,1 - 35,0 kg	8	32,0	4,45	3,33	401	1,34	4
über 35,0 kg	2	39,1	3,98	2,79	89	1,43	3
1. Lakt. 1 - 100 Tg.	3	29,9	4,34	2,98	39	1,46	3
1. Lakt. 101 - 200 Tg.							
1. Lakt. ab 200 Tg.	1	14,2	6,23	4,10	76	1,52	2
ab 2. Lakt. 1 - 100 Tg.	3	37,5	4,24	2,89	63	1,47	3
ab 2. Lakt. 101 - 200 Tg.	4	31,1	4,33	3,36	216	1,29	5
ab 2. Lakt. ab 200 Tg.	2	27,8	4,54	3,88	1207	1,17	0

Frischlaktierende Kühe (bis 100. Melktag) mit Eiweißgehalt <= 3 und/oder FEQ < 1,0 oder > 1,5

Nr.	Name	Lebensnummer	L.	Tg.	19.02.19 Eiw%	19.02.19 FEQ	12.01.19 Eiw%	12.01.19 FEQ
	BERLI	AT 318.170.738	1	84	**2,85**	1,36	**2,90**	1,18

Frischlaktierende Kühe (bis 100. Melktag) mit Eiweißgehalt <= 3 und/oder FEQ < 1,0 oder > 1,5								
					19.02.19		12.01.19	
Nr.	Name	Lebensnummer	L.	Tg.	Eiw%	FEQ	Eiw%	FEQ
	BABSI	AT 455.732.528	2	84	3,10	**1,54**	3,00	1,27
	ZENTA	AT 571.466.719	5	45	**2,84**	1,44	3,47	1,05
	ZITA	AT 818.234.429	1	95	3,12	**1,56**	**2,77**	1,49
	BABSI	AT 818.238.829	1	67	**2,98**	1,44	**2,96**	1,47
	BIRGIT	AT 891.719.622	3	55	**2,73**	1,42	3,02	1,13

Altmelkende Kühe (über 200. Melktag) mit Eiweißgehalt >= 3,8 und/oder FEQ < 1								
					19.02.19		12.01.19	
Nr.	Name	Lebensnummer	L.	Tg.	Eiw%	FEQ	Eiw%	FEQ
	ZONE	AT 201.580.328	3	321	**4,02**	1,09	**3,92**	1,01
	GINA	AT 460.761.128	2	321	3,74	1,25	3,67	**0,93**
	MARA	AT 494.063.829	1	258	**4,10**	1,52	**4,19**	1,03
	WOLLE	AT 688.121.322	3	215			**3,92**	1,15
	SOLA	AT 818.230.929	1	321			**3,92**	1,04

Betriebsdatenübersicht und Fruchtbarkeit

Tier Nr. R	Name Lebensnummer	Abkalbung Lakt. Eka/Zkz	Abk.dat. Rast/SP	Belegung und Belegstier Bel.datum Stiername	Sollkalb. Stiernummer	Gzw	R	Leistungsdaten M-kg Mbk	lfd. Laktation Standardlaktation				
	ZENTA	5	05.01.19					37,4	45	1.824	3,81	3,22	128
FL	AT 571.466.719	423						2,40					
	MELLA	4	12.09.18	05.12.18(1)	21.09.19	132	FL	29,2	160	5.699	3,87	2,95	389
FL	AT 971.750.119	410	84/84	GS MAWILL	AT 661.630.138			3,39					
	PIKE	4	28.09.18	04.12.18(1)	20.09.19	132	FL	31,2	144	5.369	4,37	3,25	409
FL	AT 353.085.822	500	67/67	GS MAWILL	AT 661.630.138			2,61					
	SULI	3	24.09.18					34,4	148	5.604	4,42	3,09	421
FL	AT 688.120.222	553		Trächtigkeitsunters. positiv				3,15					
	WOLLE	3	19.07.18	17.11.18(3)	03.09.19	132	FL	T	196	5.974	4,35	3,56	473
FL	AT 688.121.322	355	99/121	GS HELLSEHER	AT 332.704.238								
	SOLI	3	06.08.18					29,4	197	7.070	4,09	3,14	511
FL	AT 688.123.522	492						3,38					
	ZONE	3	04.04.18	30.06.18(1)	**16.04.19**	130	FL	32,6	321	12.183	3,55	3,22	825
FL	AT 201.580.328	349	87/87	GS RAPIDO	AT 155.420.338			3,14	305	11.661	3,51	3,19	781
	BIRGIT	3	26.12.18					40,8	55	2.388	3,57	2,93	155
FL	AT 891.719.622	554						3,03					
	ANNE	2	05.03.18	24.06.18(2)	**10.04.19**	130	FL	T	332	11.823	4,21	3,34	893
FL	AT 201.577.828	534	26/111	GS RAPIDO	AT 155.420.338			2,92	305	11.099	4,20	3,32	835
	GINA	2	04.04.18	10.11.18(3)	27.08.19	132	FL	23,0	321	9.291	4,26	3,57	727
FL	AT 460.761.128	368	91/220	GS MAWILL	AT 661.630.138			2,49	305	8.923	4,24	3,56	696
	BABSI	2	27.11.18					34,4	84	3.059	4,01	3,02	215
FL	AT 455.732.528	520						2,75					

Tier Nr. / R	Abkalbung Name / Lebensnummer	Lakt. / Eka/Zkz	Abk.dat. / Rast/SP	Belegung und Belegstier Bel.datum / Stiername	Sollkalb. / Stiernummer	Gzw	R	Leistungsdaten M-kg / Mbk	lfd. Laktation / Standardlaktation				
	PAUKE	1	08.08.17	13.05.18(4)	**27.02.19**	131	FL	T	461	12.669	3,72	3,38	900
FL	AT 019.286.229	27 Mo.	84/278	GS VATERLAND	AT 328.121.838			2,75	305	8.935	3,73	3,31	629
	SOLA	1	04.04.18	21.06.18(2)	**07.04.19**	130	FL	T	302	8.554	3,73	3,39	609
FL	AT 818.230.929	26 Mo.	56/78	GS RAPIDO	AT 155.420.338			2,69	302	8.554	3,73	3,39	609
	MARA	1	06.06.18					14,2	258	6.315	4,92	3,89	557
FL	AT 494.063.829	27 Mo.							200	5.468	4,93	3,85	480
	ZITA	1	16.11.18					33,6	95	3.549	4,96	2,86	278
FL	AT 818.234.429	31 Mo.						2,88					
	BABSI	1	14.12.18					31,2	67	2.340	4,34	2,97	171
FL	AT 818.238.829	30 Mo.						3,12					
	BERLI	1	27.11.18					24,8	84	2.195	4,03	3,03	155
FL	AT 318.170.738	27 Mo.						2,31					

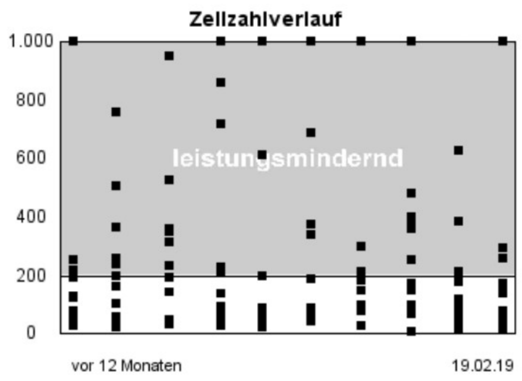
KALBINNEN		geboren	Belegung und Belegstier				Abstammung
1	LILLI	10.09.17					V: FUNAKI AT 967.079.919
WG	AT 560.427.938						M: LIN AT 201.579.128
	SELLA	05.11.16	25.05.18(1)	**11.03.19**	131	FL	V: RUKSI DE 09 44605436
FL	AT 122.265.538		GS VATERLAND	AT 328.121.838			M: SONNE AT 509.252.819
	SINDI	24.01.17	14.07.18(1)	**30.04.19**	130	FL	V: MINT DE 09 48271424
FL	AT 560.415.538		GS RAPIDO	AT 155.420.338			M: SONJA AT 265.020.928
	GINI	01.04.17					V: MAHANGO DE 09 48097266
FL	AT 190.629.838						M: GINA AT 460.761.128
	ZONI	20.04.17					V: WELTASS DE 09 48654742
FL	AT 560.417.738						M: ZONE AT 201.580.328
	LIES	06.05.17	20.10.18(1)	06.08.19	132	FL	V: MONUMENTAL DE 09 4972909
FL	AT 560.418.838		GS MAWILL	AT 661.630.138			M: LENI AT 571.464.519
	PIA	16.05.17	24.12.18(2)	10.10.19	132	FL	V: MONUMENTAL DE 09 4972909
FL	AT 560.419.938		GS MAWILL	AT 661.630.138			M: PIKE AT 353.085.822
	BIGI	20.06.17					V: MONUMENTAL DE 09 4972909
FL	AT 560.420.238						M: BIRGIT AT 891.719.622
	PAULINE	08.08.17					
FL	AT 560.424.638						M: PAUKE AT 019.286.229
	ZONUM	18.08.17	21.12.18(1)	07.10.19	132	FL	V: MONUMENTAL DE 09 4972909
FL	AT 560.425.738		GS MAWILL	AT 661.630.138			M: ZONI AT 137.570.419
	ZITA	08.11.17					V: MANDRIN AT 650.446.817
FL	AT 560.428.138						M: ZENTA AT 571.466.719
	SORAIA	04.04.18					V: GS PETERHANS AT 114.331.7
FL	AT 217.927.568						M: SOLA AT 818.230.929
	PAULA	06.06.18					V: GS PLAYER AT 500.070.129
FL	AT 565.740.768	Zwicke					M: ZAGE AT 571.458.719
	SALI	24.09.18					V: GS WILLHABEN AT 398.243.32
FL	AT 830.001.738						M: SULI AT 688.120.222
	ZIZI	16.11.18					
FL	AT 830.003.938						M: ZITA AT 818.234.429
	BIBI	27.11.18					V: GS WILD GUT AT 499.131.229
FL	AT 830.006.338						M: BABSI AT 455.732.528

KALBINNEN	geboren	Belegung und Belegstier	Abstammung
BASS FL AT 830.008.538	14.12.18		V: GS VATERLAND AT 328.121.83 M: BABSI AT 818.238.829
BINE FL AT 830.009.638	26.12.18		V: GS VATERLAND AT 328.121.83 M: BIRGIT AT 891.719.622

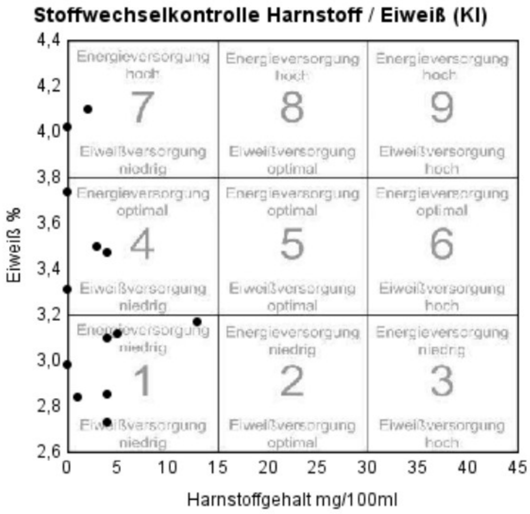
Bestandsveränderungen im Kontrollabschnitt

Zugänge		geb.	G	R	Vater	Mutter	Datum
	AT 870.037.268	09.12.18	M	FL	WORLDCUP DE 09 51373137	BLUME AT 122.722.838	15.01.19
	AT 638.511.568	11.12.18	M	FL	GS VIGOR AT 849.026.729	PETUNA AT 324.654.538	15.01.19
	AT 873.373.668	15.12.18	M	WB	GS SUPERMAN AT 229.713.81	CLARA AT 087.000.728	15.01.19
	AT 872.314.268	18.12.18	M	WB	GS SUPERMAN AT 229.713.81	SALI AT 534.084.828	29.01.19
	AT 568.832.568	20.12.18	M	FL	MANUEL AT 328.306.238	EVELYNE AT 757.775.618	29.01.19
	AT 876.043.368	22.12.18	M	FL		RADI AT 912.742.829	29.01.19
	AT 878.266.768	31.12.18	M	WB	GS HITZKOPF AT 296.991.918	STINGSI AT 275.574.119	12.02.19
	AT 872.019.468	04.01.19	M	FL	GS HERZBLUT AT 499.973.22!	STEFANIE AT 652.745.138	12.02.19
	AT 267.901.169	08.01.19	M	FL	HORIZONT DE 09 51888322	MATINA AT 665.682.717	12.02.19

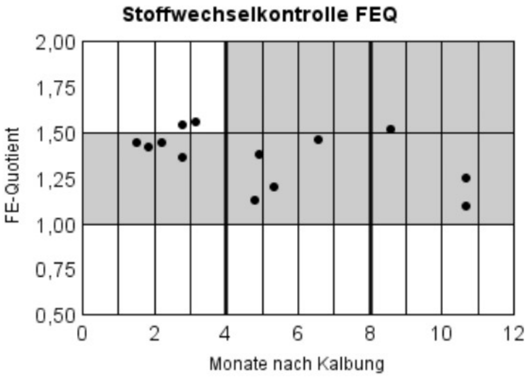
Abgänge		geb.	G	R	Datum	Grund
ZUKI	AT 023.160.669	05.01.19	W	FL	24.01.19	verendet,



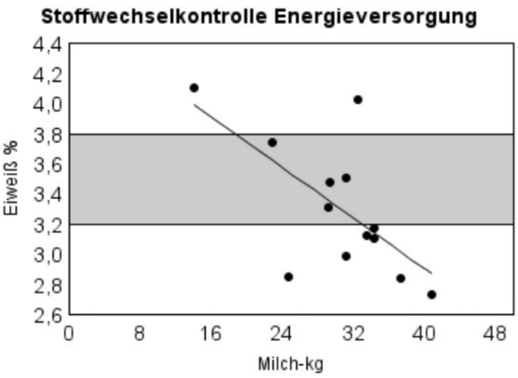
Klasse	Anz	%
über 800	1	7,7
400-800	0	0,0
200-400	2	15,4
100-200	4	30,8
bis 100	6	46,2



Klasse	Anz	%
9	0	0,0
8	0	0,0
7	2	15,4
6	0	0,0
5	0	0,0
4	4	30,8
3	0	0,0
2	0	0,0
1	7	53,8



Klasse	Anz	%
Ketosegefahr	2	15,4
normal	11	84,6
Acidosegefahr	0	0,0



Klasse	Anz	%
Energieübersch.	2	15,4
normal	4	30,8
Energiemangel	7	53,8

Annex 4

Questionary – Detection of mycotoxins and its impact on animal health and performance

Developed by Mag. med. vet. Felipe Penagos-Tabares

References are given within the questionary

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BETRIEBS CODE ➔

FRAGEBOGEN: BETRIEBSMANAGEMENT- UND HERDENBEWERTUNG

Betrieb		Ort		Bezirk			
Kontaktperson		Postleitzahl		Adresse			
		Tel.		Termin am		um	

Allgemeine Informationen

Gesamtfläche:		Betriebsart		Anbaufläche:		
Tieranzahl		Konventioneller Betrieb		Leistung pro Kuh (Durchschnitt)		______/L/Tag
Kühe in Milch	Trockensteher	Biobetrieb		**Anmerkungen**		
Rassen (% or N°)		Biodynamischer Betrieb				

Informationen zum Fütterungsmanagement

Fütterungssystem					**Rationszusammensetzung** (AGR oder TMR) (Informationen beim nächsten Besuch erhalten)	
TMR (kein-Weide)		tTMR (AGR)/Kraftfutter		Weide /tTMR (AGR)		
Weide / Kraftfutter (PC)		Andere		Welche		
TMR/AGR	______kg FM/ T/Kühe	______kg FM/T/Kuh	kg TM/T/Kuh➔	TM-Inhalt*: ______	Rationszusammensetzung (TM oder FM-Basis)	%
Fütterungsfrequenz				______/Tag		
Sammlung der Futterreste	Ja	Manchmal		Nein		
Verwertung der Futterteste						
Heu				TM-Inhalt*: ______		
Art(en)						
Stroh				TM-Inhalt*: ______		
Art(en)						
Wiesen	Ja	Nein	Fläche (m²)			
Für alle Kühe:	Ja	Nein	Wie viele:			
Weideart:						
Tage/Jahr						
Rotationszeit (Tage)		Weide, TM% Aufnahme im Sommerzeit ➔				
Silage		MS-TM-Inhalt: ______		GS-TM-Inhalt: ______		
Futtermenge (kg TM/T/Kuh)	Frühling:	Sommer:	Herbst:	Winter:		
	M					
	G					
Lagerart						
Horizontal:	Fahrsilo	Graben	Hochsilo:	Betoniert	Sauerstoffbegrenzung	
Ballen:	Rund-	Quader-	Andere:			
Art ➔	Mais		Gräser		Andere	
	Sorte		Art		Art	
Vorbereitungs-methode	Horizontal:	Fahrsilo ☐	Graben ☐	Silo Bag ☐	**Anmerkungen:**	
	Hochsilo:	Betoniert ☐	Metal	Sauerstoffbegrezend ☐		
	Ballen:	Rundballen ☐	Quaderballen ☐			
	Andere:					

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Silage Impfmittel:	M	Ja	Nein	Art/Produkt:	
	G	Ja	Nein		

Verwendung von Anti-Schimmelbehandlungen/ Anti-Mykotoxin-Zusatzmitteln

Ammoniak	Ja	Nein	Produkt:		Andere Prod/ Zusatzmittel	Ja	Nein
Propionsäure	Ja	Nein	Produkt:		Produkt:		
Produkte zur Mycotxin-Deaktivierung	Ja	Nein	Welche:				
			Wie lange:				

Schimmelpilzbefall in Futtermitteln (Wahrnehmung des Landwirtes)	☐ Häufig	Ungewöhnlich ☐	Niemals ☐
Werden die "Schimmelpilz-kugeln von Silage" vor Fütterungsvorbereitung weggeschmissen?	☐ Regelmäßig	Sporadisch ☐	Niemals ☐
Welches Futtermittel ist von Schimmelpilzbefall bzw. Verunreinigung stärker betroffen?			

Verwendung von Anti-Mykotoxin-Zusatzmittel	Ja	Nein	Produkt/Hergesteller		Dose	
Zeitraum der Nutzung von AMZ	Vom		bis		Anmerkungen:	

Voherige Mykotoxin-Analyse	Ja	Nein	Durchgeführt von (Labor):	
Ergebnisse: (Fotografieren!)	Mykotoxin		Gehalt	

Anmerkungen:

Kraftfuttermittel	____________kg TM/T/Kuh (Durchschnitt)					**→→→Kraftfutter Zusammensetzung***		
Handelsmarke:	Selbst-Hergestellt (im Betrieb) →→→					Komponenten	Kg	%
Name:	Zusammensetzung (Fofografieren) !							
Lagerbedingungen								
Anmerkungen:	Yeast- Inhalt*:	Ja	Nein	Dose*:				
	Art*:							
	Anti-Mykotoxin-Susatzmittel*:	Ja	Nein	Dose*:				
	Typ von AMZ*:							
Mineralstofffutter	Marke:							
	Produktsname:							
	kg TM/T/Kuh →							
Anmerkungen:	Yeast- Inhalt*:	Ja	Nein	Dose*:				
	Art:							
	Anti-Mykotoxin-Susatzmittel*:	Ja	Nein	Dose*:				
	Typ von AMZ*:							

Fütterung der Trockensteher (Galtzeit)

Ration							
Kraftffutter	Marke:		Produktsname:				
Yeast- Inhalt*:	Ja	Nein	Dose*:		Art*:		
Anti-Mykotoxin-Susatzmittel*:	Ja	Nein	Dose*:		Typ von AMZ*:		
Mineralstofffutter	Marke:		Produktsname:				
Yeast- Inhalt*:	Ja	Nein	Dose*:		Art*:		
Anti-Mykotoxin-Susatzmittel*:	Ja	Nein	Dose*:		Typ von AMZ*:		

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Anmerkungen:										
Landwirtschaftliche Praktiken und Management von Futter- und Futterpflanzen										
Welche Futterpflanzen werden angebaut? [Spezifische Zwecke]										
Welche Erkrankungen treten bei Ihrern Futterpflanzen am häufigsten auf?								Ährenfusariosen		
								Kolbenfäulen		
								Maisbeulenbrand		
								Andere:		
Haben Sie einen integrierten Schädlingsschutz?				Ja		Nein				
Welche dieser landwirtschaftlichen Praktiken kommen beim Anbau der Futterpflanzen zur Anwendung?										
Keine		Fruchtfolge		Schädlingsbekämpfungsmitteln (z.B. Fungizide)		Welche:			Wann:	
Betriebsgülle (Düngung)		biodynamische Präparate		Verwendung von resistenten Sorten (für Mykotoxin produzierende Krankheiten)		Welche:				
				Verwendung von Biosorten		Welche:				
				Bodenimpfmittel oder Biostimulatoren		Andere:				
Wie oft führen Sie die Pflanzenkrankheitaüberwachung durch?		nach Bedarf		Monatlich		Jährlich				
				Andere(spezifizieren)						
Anmerkungen:										

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Hygienebedingungen des Betriebes

Lagerungbereich	Bodenbeläge Qualität		Wetterfest		Schutz vor dem Zugriff von Schädlingen		Futtertrennung		Ein-und Ausgangbereich	
	Gut	Schlecht	Ja	Nein	Ja	Nein	Ja	Nein	Ja	Nein
	Trockenheit		Schädlingsbekämpfung		Anmerkungen:		Wie oft bekommt man neue Futterchargen?			
	Ja	Nein	Ja	Nein						
	Schimmel in der Silage		Farbe des Schimmels		Schimmel im Heu		Farbe des Schimmels		Anmerkungen:	
	Ja	Nein			Ja	Nein				
Mischbereich	Bodenbeläge Qualität		Wetterfest		Schutz vor dem Zugriff von Schädlingen		Sauberkeit		Ein-und Ausgangbereich	
	Gut	Schlecht	Ja	Nein	Ja	Nein	Ja	Nein	Ja	Nein
	Trockenheit		Schädlingsbekämpfung		Anmerkungen:					
	Ja	Nein	Ja	Nein						
Futterwagen	Qualität		Kein Schimmel		Kein Schmutz		Regelmäßiges Putzen		Anmerkungen:	
	Gut	Schlecht	Ja	Nein	Ja	Nein	Ja	Nein		
Fütterungsbereich	Bodenqualität		Kein Schimmel		Kein Kot/ Schmutz		Regelmäßiges Putzen		Anmerkungen:	
	Gut	Schlecht	Ja	Nein	Ja	Nein	Ja	Nein		
Trinkwasser	immer verfügbar		Saubere Ausstattungen		Sauberes Wasser		Reiningungsplan		Anmerkungen:	
	Ja	Nein	Ja	Nein	Ja	Nein	Ja	Nein		
Stall	Bodenqualität		Wetterschutz		Schutz vor dem Zugriff von Schädlingen		Allgemeine Sauberkeit		Abwesenheit der Überfüllung (kein Platz zum Liegen)	
	Gut	Schlecht	Ja	Nein	Ja	Nein	Ja	Nein	Ja	Nein
	Stallflächen	Kuhanzahl	Abwesenheit des Schimmels in Einstreumaterial		Gülleverwertung:		Wie:			
			Ja	Nein			Wie oft:			

Ja/gut = 1, Nein/schlecht =0

Schätzung des Hygienewertes	
Richtig	4+
Geringfügige Mängel	3
Erheblicher Mangel	2
Großer Mangel	1 oder 0

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COW HEALTH EVALUATION

BETRIEB CODE →

Date		Time		Farm	

COW	Fecal score[1]	BCS[2]	Rumen Score[1]	Cleanliness score[3]					
	20% (1-5)	20% (1-5)	20% (1-5)	20% (1-4) (1=clean, 4=Very dirty)					
				Rear	Thigh	Legs	Udder	Belly	Total
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
Anmerkungen:									

1. Hulsen J; Cow signals. How to understand the speech of cows. Profi Press s.r.o., Praha. 2007.
2. Ferguson, J. D., Galligan, D. T., & Thomsen, N. (1994). Principal descriptors of body condition score in Holstein cows. Journal of dairy science, 77(9), 2695-2703.
3. Ruud, L. E., Bøe, K. E., & Østerås, O. (2010). Risk factors for dirty dairy cows in Norwegian freestall systems. Journal of dairy science, 93(11), 5216-5224.

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Particle Size Distribution of TMR/(p)TMR(AGR)

Ergebnistabelle für die Untersuchung der Ration mittels Schüttelbox

Tragen Sie die kumulativen retinierten Partikel (% der gesamten Ration) in dieser Tabelle ein.

Siebporengröße	Ration Nr______		Ration Nr______		Ration Nr______		Ration Nr______	
	Gramm	%	Gramm	%	Gramm	%	Gramm	%
> 19 mm								
8 – 19 mm								
1,18 – 8 mm								
< 1,18 mm								
Summe		100		100		100		100

% =Gewicht/Summe x 100

Einordnung der Ergebnisse (Zielvorgaben) bei Verwendung einer TMR mit geschrotetem Kraftfutter (TMR 1), pelletiertem Kraftfutter (TMR 2) oder einer Teil-TMR

Schüttelbox (Penn State Particle Size Separator, PSPS, nach HEINRICHS und KONONOFF , 2002)			
Siebporengröße	**TMR 1, %**	**TMR 2, %**	**Teil-TMR, %**
> 19 mm	3 - 8	3 – 8	15 – 25
8 – 19 mm	30 - 40	35 - 45	35 – 65
1,18 – 8 mm	30 – 40	40 – 50	15 – 25
< 1,18 mm	< 20	< 10	< 8

Betriebsbesuche Tierernährung Oktober 2018

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Hygienic status of HAY (Adapted from Kamphues et al., 2014)

Overall Points		

Examination parameters		Nutritional value-related characteristics (i.e. acceptance, energy and protein content)	Points[1]	Hygienic status-related characteristics (i.e. health risks)	Points[1]
Appearance	Colour	strongly green	10	typical product	0
		lightly bleached/browned	5	with gray/white focus	-5
		strongly bleached/ browned	0	diffuse discoloured	-10
	Impurities[2]	amount of sand, dust or/and plants with low nutritional value[4]: free	10	presence[3] of mite, beetle or mould: free	0
		low	5	medium	-5
		high	0	high	-10
				presence of toxic plants (depending on species und amount)	-5
Odour		aromatic, pleasantly	5	without strange odour	0
		light hay odour	3	dull-musty nuances	-5
		flat	0	mouldy (foul, putrid, going rotten)	-10
Texture		soft, leaf-rich (few inflorescence)	15	dry	0
		leaf-poor	10		
		extremely leaf-poor	7	lightly clammy	-2
		stem-rich (many inflorescences)	2		
		strawy, hard	0	clammy-wet	-5

Estimation of nutritional value and hygienic status of hay

Nutritional value	Points	Hygiene status	Points
very good to good	40 to 32	**Proper**	0
satisfying	31 to 20	**minor deficiency[5]**	-1 to -5
moderate	19 to 10	**significant deficiency[6]**	-6 to -10
low	9 to 0	**vast deficiency[7]**	-11 to -40

[1] depending of the findings intermediate scores could be assigned for the different parameters.
[2] Shake out of fine particles, paying attention to dust development.
[3] Fine particles are to be subjected to a magnifying glass examination (in case of slight mould build-up: felt-like deposits would be observed especially on the nodes).
[4] such as thistle [Asteraceae], soft-grasses [*Holcus*]).
[5] special care must be taken with regard to storability.
[6] microbiological, especially mycological/mycotoxicological analyses are strongly recommended.
[7] high health risk, therefore should not be used it as feed.

Hygienic status of SILAGES (adapted from Kamphues et al., 2014)

Overall Points	MS		GS		Other		Which	

Examination parameters		Nutritional value-related characteristics (i.e. acceptance, energy and protein content)		Points[1]	Hygienic status-related characteristics (i.e. health risks)		Points[1]
Appearance	Colour	product-typical[2]		10	presence of white, gray, green, black colour variations e.g. mould hot spots	sporadically	-5
		moderated variations (cleared or darkened)		5			
		discoloured or gray		0		frequently	-10
	Impurities	free or low amount of weeds[3]		8	proportion of weeds and/or by-disease-modified-plant parts[4]	Free to low	0
		low amount of weeds		4		moderate	-5
		high amount of weeds		0		high	-10
Odour[5]		pleasantly from acid-aromatic to bread-like/fruity		12	lightly yeasty nuances		-3
		traces of butyric or acetic acid, pleasantly roast odour		8	evidently yeasty-alcoholic qualities		-7
		moderate butyric or acetic acid odour, intensive roast odour		4	lightly mouldy		-12
		ammonia- nuances, strong butyric, acetic acid odour, unpleasant odour		0	Intense mould, rotten or faecal odour		-17
Texture		Dry matter-content[6]:	Favourable (product-typical): 30 to 40%	5	slight to clear warming (secondary fermentation)		-5
			Unfavourable[7]: <30 - >40%	2			
		amount of sand and/or earth:	free to low	5	slight to evident loss of structure[8] (slimy coating)		-3
			moderate	2			
			high	0	degree of contamination with sand and/or earth		-5

Estimation of nutritional value and hygienic status of silage

Nutritional value	Points	Hygienic status	Points
very good to good	40 -37	**Proper**	0
satisfying (average)	36-25	**minor deficiency**[9]	-1 to-5
significantly reduced	24-13	**significant deficiency**[10]	-6 to -10
Low	12-0	**vast deficiency**[11]	-11 to -50

MS	GS	Other

[1]depending of the findings intermediate scores could be assigned for the different parameters.
[2] the colour can be influenced by the plant stadium as well as by the grain/leaf proportion.
[3] as orache (*Atriplex* spp) and similar in green feed.
[4]e.g. fungus infection such as stinking bunt of wheat produced by *Tilletia caries*, Corn smut caused by *Ustilago maydis* and anthracnose stalk rot of corn induced by *Colletotrichum graminicola*.
[5]recognizable by rubbing a handful of sample between the fingers.
[6]see the table 2.1. Estimation of DM-content of silage by hand method, for more accurate results it is also possible to use the microwave oven method (Gay et al., 2009) or a moisture tester.
[7]in very moist silages the nutrient loss will be increased by leaching; in excessively dry silages can have poor aerobic stability with high predisposition to secondary fermentation.
[8]Loss of structure is perceived like mucilaginous consistency due to microbial conversions, independent of chopping length.
[9] special care must be taken with regard to storability.
[10] microbiological, especially mycological/mycotoxicological analyses are strongly recommended.
[11] high health risk, therefore should not be used it as feed.

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Hygienic status of STRAW (adapted from Kamphues et al., 2014)

Overall Points		

Examination parameters		**Nutritional value-related characteristics** (i.e. acceptance, energy and protein content)		**Points**[1]		**Hygienic status-related characteristics** (i.e. health risks)		**Points**[1]	
Appearance	**Colour**	golden-bright		10		product-typical[2]		0	
		moderately greyed		5		dirty grey-brown-blackish		-5	
		very dirty		0		grey-white/red discoloration		-10	
	Impurities	amount of impurities	free	10		presence of	free	0	
		(stubbles, sand earth,	Low to medium	5		mites, beetles,	Low to medium	-5	
		etc):	High	0		mold or weeds[3]:	High	-10	
Odour		typical straw odour[2]		10		free of foreign odors[2]		0	
		flat, vapid		5		Slightly dull musty nuances		-5	
		odourless		0		mouldy-musty		-10	
Texture		species-typical (higher leaf mass fraction)		10		dry-brittle		0	
		Bulky (high stem proportion, low leaf-mass)		5		slightly clammy (nest by nest)		-5	
		Brushwood-like		0		clammy-moist, elastic		-10	

Estimation of nutritional value and hygienic status of straw

Nutritional value	**Points**	**Hygienic status**	**Points**
very good to good	40-30	**Proper**	0
satisfying (average)	29-16	**minor deficiency**[4]	-1 to -5
significantly reduced	15-10	**significant deficiency**[5]	-6 to -10
Low	9-0	**vast deficiency**[6]	-11 to -40

[1]Depending of the findings intermediate scores could be assigned for the different parameters.
[2]Conservation by treatment with NH_3 (Ammoniation): dark coloration and ammoniacal odour are typical. This conservation technique increases the nutritional value (↑digestibility and energy concentration) (Flachowsky et al., 1984).
[3]Verifying botanical species and its proportion, e.g. occurrence of common windgrass (*Apera spica-venti*).
[4]Special care must be taken with regard to storability.
[5]Microbiological, especially mycological/mycotoxicological analyses are strongly recommended.
[6]High health risk, therefore should not be used it as feed.

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Hygienic status of CEREAL GRAINS (adapted from Kamphues et al., 2014)

Overall Points		

Examination parameters		Nutritional value-related characteristics (i.e. acceptance, energy and protein content)		Points[1]		Hygienic status-related characteristics (i.e. health risks)		Points[1]	
Appearance	**Botanic purity**	Admixtures of other strange seeds	no detected	10		Content of weeds, Ergot	no detected	0	
			mid	5			mid	-5	
			high	0			high	-10	
	Colour[2] Shape Integrity	Product-typical		10		typical colour of grain		0	
		Minimally discoloured, black or brown colorations		5		dirty, greyed, black-brownish, violet (stained)		-5	
		moderately to highly discoloured, black or brown colorations[3], high proportion of green, narrow or flat grains (immaturity)		0		reddish (*Fusarium* infestation), superficial deposits (microrganisms), holes (pests)		-10	
	Impurities	Content of sand, small stones, husks, chaff, other extraneous components [4]	no detected	10		Content of fine particles: insects, mites, their parts, faeces of rodents, coatings of dirtiness and/or mould.	no detected	0	
			mid	5			mid	-5	
			high	0			high	-10	
Odour		product-typical		10		product-typical		0	
		Acid or ammonia-like[5]		5		mil yeasty, alcoholic, mouldy		-5	
		burnt[6], disagreeable		0		strong musty, mouldy, yeasty, burnt		-10	
Texture		Hard		10		dry		0	
		slightly softer, elastic		5		a bit clammy		-5	
		soft, elastic		0		clammy-wet, agglutinations		-10	
Flavour[7]		Cereal-typical, flour-like, palatable		10		Cereal-typical, flour-like, palatable		0	
		Untypical, unpalatable, distasteful		0		distasteful, bitter		-10	

Estimation of nutritional value and hygienic status of cereal grains

Nutritional value	Points	Hygienic status	Points
very good to good	60-48	**Proper**	0
satisfying (average)	47-34	**minor deficiency[8]**	-1 to -5
significantly reduced	33-20	**significant deficiency[9]**	-6 to -20
Low	19-0	**vast deficiency[10]**	-21 to -60

[1]Depending of the findings intermediate scores could be assigned for the different parameters.
[2] Consider variations between species and varieties (e.g. sweet, dent or flint corn).
[3] Damages by overdrying/heating).
[4] Can induce reduction of the feed digestive rate.
[5] Consider conservation process by treatment with organic acids or NH_3 (Ammoniation) (Jones et al., 1974; Peplinski et al., 1978).
[6]Indicates overheating.
[7]Do not perform this analysis, if previous parameters have shown low or reduced scorings on nutritional value and/or (especially) hygienic status. If so, rate it on the basis of the odour assessment.
[8]Special care must be taken with regard to storability.
[9]Microbiological, especially mycological/mycotoxicological analyses are strongly recommended.
[10]High health risk, therefore should not be used it as feed.

Hygienic status of CONCENTRATE AND PELLETED FEEDS (adapted from Kamphues et al., 2014)

Overall Points		

Examination parameters		Nutritional value-related characteristics (i.e. acceptance, energy and protein content)		Points[1]		Hygienic status-related characteristics (i.e. health risks)		Points[1]	
Appearance	Colour[2] Shape	degree of heterogeneity (in colour, diameter and/or shape)	low	10		Content of washed-out, gray, dirty, macerated pellets/feed	nought	0	
		and content of powdery	mid	5			low	-5	
		material (for pellets)	high	0			high	-10	
	Impurities	content of sand, small stones, husks, chaff, other extraneous components[3]	low	10		Content of insects, insect fragments, mites, webs (storage pests), rodent faeces, different kind of pellets	nought	0	
			mid	5			mid	-5	
			high	0			high	-10	
Odour[4]		product-typical		10		product-typical		0	
		mildly acid, rancid, burnt or disagreeable		5		Intensity of mouldy, alcoholic[5a], sweet[5b], rancid[5c] or putrid/ cadaverous[5d]	mid	-5	
		highly acid, rancid, burnt or disagreeable		0			high	-10	
Texture		degree of disintegration	low	10		dry		0	
		(pellets)/ of compaction/	mid	5		mildly clammy (agglutinations)		-5	
		agglutinations (for powder)	high	0		wet, very clumpy		-10	
Flavour[6]		Palatable		10		Palatable		0	
		Untypical, unpalatable, distasteful		0		distasteful, burnt, bitter		-10	

Estimation of nutritional value and hygienic status of concentrate and pelleted feeds

Nutritional value	Points	Hygienic status	Points
Very good to good	50 -37	**Proper**	0
satisfying (average)	36-25	**minor deficiency**[7]	-1 to -5
significantly reduced	24-13	**significant deficiency**[8]	-6 to -20
Low	12-0	**vast deficiency**[9]	-11 to -50

[1] Depending of the findings intermediate scores could be assigned for the different parameters.
[2] brown-black portions (e.g. husks of rapeseed of sun flower seed, rapeseed, canola seed, cottonseed, among others), blackish (reheating) white, blue-grey colorations (mould).
[3] can reduce of the palatability and/or feed digestive rate
[4] the ingredients should be considered e.g. feedstuffs such as fish, fish meal, grass meal, rape seed, fruit/vegetable by products, etc, as well as acids and highly aromatic ingredients like vanillin, herbal extracts/essential oils [mint, anise, eucalyptus, oregano, etc], among others
[5a]yeast infestation; [5b]honey-like: mite infestation; [5c]fat oxidation; [5d]protein degradation.
[6]Do not perform this analysis, if previous parameters have shown low or reduced scorings on nutritional value and/or (especially) hygienic status. If so, rate it on the basis of the odour assessment.
[7]Special care must be taken with regard to storability.
[8]Microbiological, especially mycological/mycotoxicological analyses are strongly recommended.
[9]High health risk, therefore should not be used it as feed.

Annex 5

Tab. 15 Descriptions of abbreviations used in the principal component analysis.

Abbreviation	Description	Comments
Forage	% of forage in diet DM	
Conc_total	% concentrate in diet DM	
add_Conc	% added concentrate (not in basal mixed diet)	
Maize_silage	% Maize silage in the dietary forage DM	
Grass_silage	% Grass silage in the dietary forage DM	
DMI	Estimated dry matter intake (kg/d)	
basalDM	% dry matter of basal diet DM	
BasalOM	% organic matter of basal diet DM	
BasalCP	% CP of basal diet DM	
BasalAsh	% crude ash of basal diet DM	
BasalFat	% CF of basal diet DM	
BasalNDF	% neutral detergent fiber of basal diet DM	
BasalNFC	% non-fiber carbohydrates of basal diet DM	
Sieve1	% large particle > 19 mm	
Sieve2	% particles 8-19 mm	
Sieve3	% particles 1.18-8 mm	
Sieve4	% fine particles < 1.18 mm	
Fecal	Fecal score	
HS	% Holstein cows in the herd	
BCS	Body condition score	
Rumen	Rumen score	
Hyg_Rear	Hygienic/cleanliness score of rear	
Hyg_Thigh	Hygienic/cleanliness score of thighs	
Hyg_Legs	Hygienic/cleanliness score of legs	
Hyg_Udder	Hygienic/cleanliness score of udders	
Hyg_Belly	Hygienic/cleanliness score of belly	
Hyg_Total	Total cow hygenic/cleanliness score	
Parity	Average number of parities	
DIM	Day in milk (d)	
milk_yield	Milk yield (kg/d)	
milk_fat	% milk fat	
milk_protein	% milk protein	
SCC	Somatic cell counts ($\times 10^3$ cells/ml)	
Fattoprotein	Milk fat to protein ratio	
MUN	Milk urea nitrogen (mg/dL)	
Ketomir	% cows detected with KetoMIR category over 1 year	LKV reported
AbnormalMilk	% lactating cows with abnormal milk constituents	% of lactating cows
Culled_fert	% cows in herd culled due to fertility problems	% of herd size

FertilityTreat	% cows in herd treated due to fertility problems	% of herd size
Insem3	% cows in herd with insemination three times or more	% of herd size
ClawTreat	% cows in herd treated due to claw and limb problems	% of herd size
othertreatments	% cows in herd treated due to other problems	% of herd size
SCC200	% lactating cows with SCC > 200,000 cells/ml	% of lactating cows
Acidosis	% lactating cows at risk of acidosis based on the fat to protein ratio < 1.0	% of lactating cows
Ketosis	% early lactating cows (< 4 m in lactation) with fat to protein ratio > 1.5	% of lactating cows
Enery_def	% lactating cows with category 1-3 of milk protein to MUN ratio	% of lactating cows
Energy_plus	% lactating cows with category 7-9 of milk protein to MUN ratio	% of lactating cows

DM = dry matter, d = day, MUN = milk urea nitrogen, LKV = Landeskontrollverband, m = month, KetoMIR = risk of ketosis from milk mean infrared (MIR) spectrum, SCC = somatic cell count, CP = crude protein; CF = crude fat.