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Advances in Dairy Research

Review Article

The Obstacles to Using Milk Composition as Management Tool in Dairy Cattle Farms

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ABSTRACT

The main objective of this discussion highlights the use of milk composition data as a management tool. Milk composition, and in particular, milk fat content, milk protein content and the ratio of milk fat/protein may be significantly altered due to a variety of factors.

The development of milk production in the world in the last 10 years reflects the enormous performance potential of the herds and the farms. However, there is a concomitant worsening of fertility and an increase in the number of animals that leave the herd due to metabolic disorders, infertility, hoof disease and mastitis. In order to reduce such losses, indicators are required that indicate a disease or the risk of a disease at an early stage. In addition to the kidney, the mammary gland is the most important excretory organ of the intermediately converted nutrients. for a range of nutrients, milk reflects the quality and/or quantity of these transformation processes, and thus milk is a medium with which we can prove the success of our feeding and recognize some important feeding and management errors. But this tool can never replace close monitoring of a herd by the farmer and appropriate veterinary care but may be used as an efficient alert system for preventing health disorders in cows. Further research based on larger data set even entire population of animals is necessary to confirm the results obtained in this study.

Keywords: Disorders; Cattle; Fat; Milk; Protein

Abbreviations: BHBA: β-Hydroxybutyrate; NEFA: Non-Esterified Fatty Acids; FPR: Fat to Protein ratio; NEB: Negative Energy Balance; NDF: Neutral Detergent Fiber; PUFA: Polyunsaturated Fatty Acid; SARA: Subacute Ruminal Acidosis; DHI: Dairy Herd Improvement

INTRODUCTION

Fat-Protein Ratio (FPR) as an indicator for lactation dairy cows

Transition period and early lactation are critical points in the life of a dairy cow. In addition to disorders of the birth process and the associated complications, especially metabolic disorders are of central importance. Metabolism undergoes profound changes at the onset of lactation, and to make matters worse, that the feed intake is often can't meet the nutrient and energy needs caused by the removal of milk and thus a negative energy balance (NEB) exists.

The majority of metabolic disorders, however, do not appear clinically but are subliminal. It is therefore important to identify affected or endangered animals by means of auxiliary features. Previous studies reported average farm prevalence of 12% to 14% for subclinical ketosis (SCK) [1-3], but prevalence of subclinical ketosis (depending on the selected "cutoff" of the BHB concentration) had ranged in the data of literature from 8.9% to 80% (Table 1).

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Table 1: Prevalence of subclinical ketosis.

Author	Prevalence
Schäfer M and Bethe W [4]	16.3%; 37% at age>10 years
Berglund B and Larsson K [5]	26.1% in average; 12.4% at 1st lactation; 31.7% at 2nd lactation; 30% at 3rd lactation; 36% at 4th lactation
Kauppinen K [6]	31.8%
Dohoo IR and Martin SW [7]	12.1% in study; to 34% in tested herds
Andersson L and Emanuelson U [8]	8.9%
Markusfeld O [9]	30.4%
Rossow N and Bolduan [10]	30%
Duffield TF, et al. [2]	12-14%
Geishauser T, et al. [11]	25%
Jorritsma R, et al. [12]	14% (Netherlands)
Duffield TF, et al. [13]	59% (cut-off point 1.2 mmol / l); 43% (Cutoff point 1.4 mmol / l) (Canada)
Mcart JA, et al. [14]	43.2%; highest incidence on 5 days postpartum
Suthar VS, et al. [15]	Average 21.8%; 11.2-36.6% (Europe)
Ospina PA, et al. [16]	18% (cut-off point 1.2 mmol / l)
Berge AC and Vertenten G [17]	Overall, 39% (Europe); 31% in Italy, UK; 43% in Germany 46% in Netherlands; 53% in France
Raboisson D et al. [18]	25% in Europa

On a herd basis, SCK can result in a loss of 78$ per cow due to less milk yield [13], increased risk of clinical ketosis [19], developed risk of displaced abomasum (DA) [20] can result in a loss of 305 to 690$ per cow due to less milk/veterinary expenses [21], increased risk of removal from the herd [14], increased of mastitis [22], and reduced reproductive performance Walsh RB, et al. [23]. FPR can be a useful tool to monitor the prevalence of subclinical ketosis in your herd, as it has advantages can be summarized as follows:

- The other tests (as BHBA) are costly compared with cow-side tests (FPR) and require time for laboratory analysis.
- It is an easy to be calculated volume, as both fat and protein levels are routinely derived from milk recording data at farms.
- It can be an assessment of BHBA levels with FPR by a non-intrusive technique.
- FPR allowed for inferences on an energy balance of cow and flagging of SCK suspicious herds for further testing to prevent disease occurrence and milk losses.

Fat and protein in milk

Milk contains about 87% water, 4.8 to 5.0% of lactose, 3.5 to 4.5% fat, 3.0 to 3.4% protein and 1% mineral salts [24]. With the progress in the stage of lactation, energy balance and milk yield tend to differ which together has its contribution in fluctuating the concentration of the milk components [25]. Milk fat increases significantly as the milking progresses with foremilk sample having low fat concentration [26]. Since high fat percentage represents NEB, milk samples might underestimate the presence of NEB. On the other hand, milk protein decreases towards the end of milking and during NEB [26].

LITERATURE REVIEW

Milk fat is composed of triacylglycerol (TAG) with different lengths; fatty acids entering the composition of TAG have two different origins, namely *de novo* synthesis by the mammary gland and uptake from the bloodstream (which are formed by 65% of acetate or butyrate in rumen). Fatty acids present in the blood originate either from the diet (10%) or from lipolysis (25%). They vary both in terms of length and saturation [24].

According to De Kruif et al. [27], the milk fat content correlates negatively with milk yield, with the increase in milk yield; it decreases until the 60th to 80th day of lactation in order to increase again with a decline in milk yield. The cow reaches the highest milk fat content in late lactation [28]. The reference range is between 3.5% and 4.5% depending on the race [29]. In Bavaria, the average fat content of all tested cows in 2003 was 4.15% [30]. The feeding and the metabolism have an influence on the milk fat through the fiber structure and content of the diet and via the body fat mobilization. A lack of structurally carbohydrate in the diet, an energy deficit, as well as fat mobilization syndrome and anorexia lead to increased fat concentrations in the milk [31,32].

Milk fat is measured routinely in dairy herds via herd tests. During NEB, milk production decreases due to low availability of glucose, and very low-density lipoproteins (VLDLs) which are formed in the liver as a result of fat mobilization are taken up by the udder. These two factors cause elevation of milk fat [33]. Therefore, milk fat is negatively correlated with energy balance [31], with increases in milk fat paralleling increases in blood ketone concentrations [13]. Duffield et al. [2] showed that a 1% increase in milk fat was associated with a more than two-fold increase in the risk of subclinical ketosis, while [34] reported that the threshold value of milk fat which indicated hyperketonemia was ≥ 4.2%. However, because milk fat was strongly influenced by nutritional, genetic, and environmental factors, the predictive value of this threshold was poor.

To counter this some studies have suggested that change in milk fat percentage, or, perhaps milk fat to protein ratio, should be the preferred measure [33]. Graphical comparison of milk yield and milk fat can be used to assess crude fiber supply [27,35]. At the beginning of lactation, higher fat levels indicate the presence of subclinical ketoses [27]. Also, fat content is a higher at the beginning of milking. Low milk fat levels indicate deficiencies in crude fiber supply and subclinical rumen acidosis De Kruif et al. [27,36]. The maximum correlation is made between the low point of the energy balance and a decline in the milk fat concentration [33].

Milk protein consists of 80% casein and 10% lactoglobulins and is made up of essential and non-essential amino acids plasma derived from microbial protein in the rumen [24]. While some of the whey proteins such as immunoglobulin's and serum albumin originate from the bloodstream, most of the milk proteins are synthesized by the mammary gland. The amino acids used for these syntheses are either derived from the bloodstream or synthesized by the gland [37]. The milk protein content is highest at the early lactation and in late lactation [28].

The low point is on the third month of lactation [27], due to lactation, milk protein levels vary between 3.2% and 3.8% [29]. In Bavaria, the average protein content in 2003 was 3.52% [30]. The graphics comparison of milk yield and milk protein content allows an assessment of the energy efficiency of feeding De Kruif et al. [27,35]. The amount of protein in the milk is influenced by the energy content and also by the protein content in the feed. Energy or protein deficiency leads to falling protein levels in the milk; however, an energy or protein excess has no effect on the protein concentration [24]. Above all, mastitis influences the qualitative composition of proteins [29]. Milk protein levels below 3.2% indicate a lack of energy and subclinical ketoses at the early lactation and are typical for an increased incidence of silent heat.

Milk protein levels below 3.2% indicate a lack of energy and subclinical ketoses at the early lactation and are typical for an increased incidence of silent estrus. They can also be combined with increased milk fat concentrations [27,38]. Like milk fat, milk protein is also routinely measured as part of herd testing on commercial farms. Milk protein has often been used alongside milk fat to create a fat: protein ratio. Indeed, Krogh MA, Toft N, Enevoldsen [39] recommended using the ratio instead of milk fat alone as they believed that protein percentage was "rather stable and cow specific" and could therefore be used as a method of adjusting for a "cow-effect". However, Madouasse et al. [40] concluded that the tendency of milk protein to decrease more rapidly during early lactation compared with milk fat caused an initial increase followed by a decrease in the milk fat to protein ratio, which made the ratio ambiguous to interpret at the time when information about NEB is most needed.

Furthermore, utilizing a single value as a ratio loses information compared to using the two values together; this review will therefore focus on the impact of energy status on the milk protein percentage alone. Even though milk protein yield in milk is more related with the genetics of the animal compared to nutrition, there are some evidences that support milk protein synthesis in mammary gland highly related with energy availability [41]. Reduction in milk protein due to the deficiency in energy and proteins supply caused by feed restriction Gross et al. [42] also supports the role of energy balance for milk protein yield. Improved energy balance minimizes protein utilization for energy, facilitating more protein availability for milk protein yield [43].

Moreover, milk protein is reduced in high producing cows suffering from NEB because milk protein synthesis requires there to be sufficient glucose available to spare the amino acids used for milk protein synthesis, which would otherwise be used for gluconeogenesis [44]. The influencing factors on milk content of fat and protein can be summarized as follows: The lack of energy (increased demand absolute relative to low supply of energy) leads to increased fat degradation (lipolysis) and increased milk fat synthesis, thus milk content of fat increases. If there is still a lack of protein, in addition to a lack of feed intake, insufficient protein will no longer be provided by the microorganisms in the rumen and, consequently, the milk protein synthesis and the milk content of protein decreases.

The third consequence of the lack of energy is a reduced lactose formation and thus declined in milk yield. Due to the quotient formation, the opposing changes in these two parameters in the event of a deficiency or/and the dependence on the quantity of milk minimized by eliminating volume reference. The diagnostic use is provided by the fact that both parameters are determined in the context of milk performance or quality controls. However, the great variability especially of the lipolysis-dependent milk fat synthesis in the first days postpartum. In addition, stable concentrations of fat and protein milk at different times during lactation.

Effect Negative Energy balance (NEB) on Fat-Protein ratio (FPR) in milk

Energy balance (EB) in dairy cows is defined as the difference between energy intake from feed and energy required for body maintenance, production and gestation Alawneh et al. [45,46]. Negative energy balance (NEB) results in animals losing body condition. Metabolic and calving stress is thought to affect the fat-protein ratio (FPR) in milk. The FPR differs between cows and depends on the lactation stage. It is often high in early lactation when NEB is most likely to occur [47].

The nutrient demand of lactation typically exceeds the dietary intake potential in an early postpartum period which often results in a varying extent of NEB [48]. High producing dairy cows mobilize their body fat, and to some extent, protein reserves in order to sustain their milk production which leads animals to enter a state of NEB until energy intake meets the output requirements Knop et al. [49,50].

In energy deficit condition, cows mobilize fat from their body which reserves to balance the energy deficit in various tissues and increases non-esterified fatty acids (NEFA) in the liver [51], and allocate glucose to the udder for milk synthesis. This biological process results in increased fat synthesis within the udder [52], and consequently the percentage of fat in milk. At the same time, inadequate intake of fermentable energy-spending carbohydrates can also cause insufficient protein synthesis through ruminal bacteria.

The flow of amino acids to the udder is compromised, thus reducing the protein percentage in milk [53]. Both of these processes result in an increased milk fat to protein ratio (FPR) [47]. In the experiment of Gruber et al. [54] the FPR was higher in cows which received a low energy diet at the beginning of lactation.

They explained this by adipose tissue mobilization due to energy undersupply, followed by an increase of milk fat content and a decreased milk protein content caused by a decrease of microbial protein synthesis in the rumen. The enormous importance of the time of the detection of the FPR as a function of the start of lactation is also shown by Buttchereit et al. [55]. Possible causes leading to a deepening of the energy deficit are mentioned by Rossow and Staufenbiel [56]:

- Oversupply of proteins,
- Poor quality of feed.
- Excessive concentrate supply with lack of structural effective crude fiber.
- So-called triggered diseases such as acute puerperal mastitis,
- High-fat deposition at an antepartum (this leads to the increase in the concentration of free fatty acids in the blood and to limit feed intake after parturition).

A sufficiently close negative relationship between FPR and energy balance has to be mentioned in the early lactation (Table 2) [57].

Table 2: Correlations (r) of selected traits in milk and energy balance* for high yielding Holstein cows**.

Parameters /Characteristics	r	p-value
Fat/lactose ratio (FLR)	- 0.589	< 0.001
Fat/protein ratio (FPR)	-0.496	< 0.001
Acetone contentin milk	- 0.410	< 0.001
Urea	0.103	0.002

Source: [31]. *1st to 10th week postpartum; **Average level of performance: 9,434 kg of milk in 305 days.

Reference values for cut-off

The cut-off point is the value at which a higher susceptibility to diseases becomes visible or a feed or performance depression occurs. Various publications report that the Fat-Protein ratio (FPR) and the fat-lactose ratio (FLR) in milk can be monitored to identify the cows subject to risk of developing subclinical ketosis, as well as, to improve the fertility indices in the herd, but the data reliability and the limits are very different [58-67].

The different limit values in the literature are shown in Table 3. The assessment of reliability ranges from "suitable for energy deficiency or ketosis detection", to "only suitable as a herd but not as an individual animal parameter "unsuitable".

Table 3: Limits from the literature for FPR (fat-protein ratio) as an indication of lack of energy or sick of ketosis.

Author	FPR
Wolter W, Kloppert B, Casteneda H, Zschök M and Vagts H [67-69]	>1.3
Hagert C, Institute for Animal Production Dummerstorf and Čejna V, Chládek G [60,63,70]	>1.4
Heuer C, Schukken YH, Dobbelaar P, Hagmüller W and Paura L, Jonkus D, Ruska D [51,61,71]	>1.5

In a Canadian study, a fat-protein ratio of 1.5 or greater was considered as a clear indication of the diagnosis of subclinical ketosis. De Boer et al. [72] confirmed that it couldn't be detected a significant relation between the milk composition and the ketosis. Drackley et al. [73] showed a reduction in milk protein with ketosis, but not one of milk fat. Milk content of fat must be assessed as a function of the lactation stage of animals [74].

The two milk ingredients fat and protein are of great importance when assessing the energy supply and the level of metabolic risk, especially as they are collected monthly for milk control over the total stock [75-77]. Kümel-Möllering et al. [77] observed that a reduced milk content of protein and an increased milk content of fat favor increased fat mobilization and thus a ketosis suspicion. Toni et al. [78] examined the feasibility of the FPR about a week after calving. About 1500 Italian Holstein cows were evaluated, on the 7th day (postpartum) a milk sample was drawn and the FPR was determined in milk.

Animals with FPR ≥ 2.0 (7th day postpartum) showed an increased incidence of retained placenta, left displaced abomasum, metritis, and clinical endometritis, and increased risk of being culled from the herd. Subclinical ketosis was associated with a higher milk yield, a higher milk fat percentage, and a lower milk protein percentage [79]. Vlček et al. [80] indicated that the FPR have a negative impact on milk yield and reflect the risk of subclinical ketosis or sub-acute ruminal acidosis.

Herds with ketosis problems in early lactation cows also tend to have increased incidence of the displaced abomasum (>8%) and increased herd removals in the first 60 days in milk (<8%). Affected herds may also have a higher proportion (>40%) in cows with milk fat to true protein percentage below 0.70 at first test after calving [81]. However, none of these clinical findings is definitive evidence for a ketosis problem in a herd. A quantitative evaluation of the prevalence of ketosis is extremely useful in most dairy herds.

According to Duffield et al. [2] milk fat and milk protein concentration of the animals for milk performance tests and the combination of these parameters is not a useful method to diagnose subclinical ketosis since observed that the best cutoff value to diagnose subclinical ketosis (BHBA ≥ 1.2 mmol/L) in the first 65 days in milk (DIM) was FPR >1.33 but the sensitivity and specificity were only 58% and 69%, respectively. Geishauser et al. [82] showed that FPR in first DHI test milk might be useful as a test for subsequently displaced abomasum in dairy cows, and using the cutoff value of 1.4, the sensitivity and specificity of FPR for displaced abomasum were 80% and 69% respectively. Krogh et al. [39] compared using the KetoLac test kit (Sanwa Kagaku Kenkyusho Co. Ltd., Nagoya, Japan) for ß-hydroxybutyrate in milk, the Keto-Stix with urine, and using the FPR for determination of ketosis during 7 to 21 DIM and having a test-date for milk fat and protein within 1d before the day of the ketosis tests. Test results of >4 mmol/L of acetoacetate in urine, >200 mmol/L of ß-hydroxybutyrate in milk, and > 1.5 FPR were used as the cut-off point for positive indication of ketosis. The overall prevalence of ketosis was 10% and 12% based on the milk and urine tests for ketones, respectively. The specificity for the milk and urine tests were high (99%) but lower for the FPR (79%), and the sensitivity was highest for the urine test (78%) and followed by the FPR (63%) and the milk test (58%).

In the FPR, the authors do not agree on the level of the value. The optimum FPR has been previously established to be between 1.2 and 1.4 for healthy cows [83]. A lower FPR (<1.2) indicates to subclinical rumen acidosis, which endangers the cow's reproductive abilities, whereas a FPR greater than 1.4 reflects potential an energy deficit and subclinical ketosis, whereas Duffield T [84] sets 1.33 as a high margin Eicher [35], Richardt W and Mahlkow-Nerge K [85,86] proposed the optimal range of FPR between 1.1-1.5, it also is noted that rumen acidosis is suspected in when FPR is below 1.1. In addition, a study of the receiver operating characteristics indicated that a FPR higher than 1.34 offers a fair prediction of reproduction problems in dairy herds [87-90].

Fulfillment research on Holstein cows, Čejna and Chládek [70] have indicated that the optimum FPR was between 1.2 and 1.4 Dirksen et al. [74] assume a balanced or positive energy supply at a FPR of ≤ 1.4. The animals in the early lactation remained unaffected. FPR >1.4 from the 4th to 6th lactation week is classified as increased non-physiologically. The FPR can be better assessed by comparing the mean values of animals of a lactation section, a performance group or by comparing the mean values of a group with those from the previous lactation. The assessment of the energy metabolism of the animals is also possible by comparison with the FPR of animals with an average milk yield, which can be derived from the need for adequate energy supply.

The FPR serves as an indicator for a change in fat and carbohydrate metabolism. In the literature, different FPR are found as a threshold for a metabolic risk. Gravert et al. [76,77] were given the FPR from the first milk control, so the value within the first lactation month, as particularly significant in terms of metabolic risk. If a value of FPR exceeds 1.3, it is considered to be a risk. The highest value of 1.5 is derived from the studies of Duffield et al. and Kraft et al. [88,89]. According to Heuer et al. and Kraft et al. [51,90] the FPR is a better indicator of diseases and fertility disorders than the body condition score or its change. The reference range for the FPR is between 1.0 and 1.5 or optimally at 1.25. It is increased in energy and/or protein deficiency in the feed ration, in the fat mobilization syndrome and increased lipolysis. Crude fiber deficiency and rumen acidosis reduce FPR [29].

At the early lactation, the FPR can be at values above 1.5. Such cows produce more milk at the expense of their body energy and protein reserves; as a result, there is an increased risk of ketosis, abomasum displacement, ovarian cysts, lameness and mastitis. The graphical comparison of milk yield and FPR makes it possible for early detection of ketosis in cows [27,35]. While Jenkins et al. [91] demonstrate that FPR >1.5 is not indicated for treatment. Lower cut-offs should be used for screening, the treatment based on FPR alone may not be necessary, on the other hand, given the high sensitivity of FPR >1.42 or lower (>1.35 or >1.25), these cut-offs could be used as a screening test so not all the cows would have to be checked if a herd has a systematic monitoring schedule for diagnosis of subclinical ketosis. In summary, FPR can be better used to screen cows for subclinical ketosis, but not as a final diagnostic for the administration of treatments.

FPR greater than or equal to 1.5 indicates for increased fat mobilization, FPR below or equal to expression for a high decrease in milk content of fat such as may be observed when fed a low fiber diets, high soluble carbohydrate diets or depletion of body fat stores [92]. The level of the protein content at the time of the lactation peak is also determined by the level of microbial protein synthesis, flow protein and easily available carbohydrates [93].

The information value of the FPR increases significantly from the 3rd to 5th week of lactation [89]. Čejna and Chládek G [70] have also reported that Milk content of fat will be higher during the first third of the lactation due to the rapid mobilization of fat post-parturition. About 50% of the fatty acids (FA) in milk originate from the diet and 50% from adipose tissue, but the contribution by adipose tissue is much higher in an early lactation, this results in not only higher milk fat concentration but also milk with an increased portion of long chain fatty acids and lower proportion of short chain fatty acids compared to later stages [94], because of the effect of DIM on milk fat concentration, milk fat can be monitored as an indicator of the risk for ketosis [95].

In a study by Čejna and Chládek [70], during the first third of lactation the FPR ranged between 1.45 and 1.91, and were higher compared to the rest of the lactation stages, the recommended FPR for used in this study was 1.05 to 1.18 in Holstein cows.

FPR >1.5 shows a moderate relationship to the energy balance only in the first weeks after the calving. Low values in high-performance herds should be interpreted with caution since FPR <1 tends to indicate an insufficient supply of structurally effective crude fiber (acidosis) Staufenbiel et al. [92,96].

In a recent work within the EU project 'Robust Milk' (www.robustmilk.eu), [97] proposed to use the maximum value of the FPR from 2nd to 5th week postpartum in deviation from that of the total lactation as an indicator of the cow's health and metabolic stability. Although this proposal impresses an idea to allow individual animal variations of the FPR during the whole lactation, but to define just the deviation from it as a feature. However, the proposal has the disadvantage that under this definition complete lactations must be present so that the deviation can be formed at all, especially those cows that already left the farm for health problems associated with negative energy balance in the first lactation but are not recorded when the lactation ended.

Brade et al. [98] found a significant influence of FPR on the culling rate at beginning of lactation. According to Römer A and Wangler et al. [99,100], very early culling at beginning of lactation is relatively common and, therefore, contribute especially to the reduction of the useful life. So, it makes sense to examine several measures of FPR, which is calculated exclusively from data at early lactation to investigate in relation to the herd. The FPR for the herd is readily available from the Dairy Herd Improvement (DHI) test days, but FPR for an individual cow at given DIM when cows are most at risk for ketosis require on-farm analytical tools for milk composition.

The obstacles to using fat to protein milk ratio

Normal milk fat percentage depends greatly on breed, season, and days in milk. While nutritional causes of milk fat depression only become a concern when these three major factors have already been checked and it has been determined that the problem is for real. However, it should be noted that there are many other factors influencing the milk fat test, which may give us false results such as (milk yield, stage of lactation, milking process, a milk sample, strip samples, laboratory methods, feed delivery and access, feed bunk management, presence of some diseases as Mastitis).

The level of milk fat percentage, as well as the composition of that fat in cows, is controlled through a variety of genetic and nutritional influences. Some nutritional influences on milk fat include level of unsaturated fat, readily fermented carbohydrates (starch and sugars), effective NEF (eNDF), the physical structure (peNDF) of the ration (particle size distribution) used to buffer the rumen [101], long fiber particles [102], the management and timing of feeds, and the use of rumen buffering agents, yeasts or the ingestion of molds [103].

Milk fat test is normally about 0.25 percent lower in the summer than in the fall months. This effect is not completely understood but could be mediated by increased risk for subacute ruminal acidosis (SARA). A common misconception, however, is that acidosis is a prerequisite for Milk fat depression to occur. This is not the case, and in most situations, rumen health appears excellent and there are no overt signs of ruminal acidosis [104].

DISCUSSION

Cows are apparently at higher risk for SARA in the summer due to heat stress, which alters their acid-base balance and makes it difficult for them to maintain normal rumen buffering. Other causes of increased SARA in the summer months could include atypical meal patterns in response to heat avoidance and ration formulation errors made when nutritionists attempt to compensate for reduced dry matter intake during heat stress by decreasing dietary fiber [105]. This only makes cow performance and milk fat test worse. However, it appears the young, fresh, immature, pasture fed to some Irish grazing dairy cows in early summer can, unfortunately, be associated on some farms with a large decline in milk fat production, that can in some cases be difficult to recover from for the remainder of the grazing season. The reality is that on some farms, the grass-only a system can be ‘the perfect storm’ for causing milk fat depression.

There are several theories as to why milk fat production drops, all of which are in some part related to rumen microbial processes. Trials have been strongly refuted now two theories that volatile fatty acid production or increased production of propionate in the rumen due to feeding starch-rich diets would have a direct effect on milk fat production. The theory of milk fat depression and now most widely accepted is ‘the bio hydrogenation theory’ [106].

The bio hydrogenation theory represents a combining concept to explain the basis for diet-induced milk fat depression where under certain dietary influences and, thus, rumen conditions, typical pathways of rumen bio hydrogenation of PUFAs are altered to produce fatty acid intermediates. These intermediates of rumen fatty acid bio hydrogenation then escape the rumen, are absorbed, and travel via the blood to the mammary gland where they signal a decreased expression of key mammary lipogenic enzymes that are necessary for milk fat production in the mammary gland. These intermediates of PUFA metabolism in the rumen are isomers of conjugated linoleic acid (CLA) which is a necessary intermediate in the bio hydrogenation of PUFA to give a saturated fatty acid end product that is of use to the cow. However, three specific types of these CLA isomers have been found to be potent at inhibiting milk fat synthesis. The CLA isomer most noted for reducing milk fat is known as trans-10, cis-12 CLA [106].

Milking frequency has also affected on milk fat and protein percentages Smith JW, Ely LO, Graves WM, Gilson WD [107] reported that milk fat and protein percentages were significantly lower in herds milking 3 times a day than in those milking twice a day. However, Allen DB, DePeters EJ, Laben RC [108] reported only slightly lower milk fat percentage from cows milked 3 times compared with cows milked twice a day, and Amos HE, Kiser T, Loewenstein M and DePeters EJ, Smith NE, Acedo-Rico J [109,110] indicated that milk composition was not affected by milking frequency. The few studies that reported on once-a-day milking indicated an increase in fat content [111,112].

Laboratory methods for milk fat testing are notoriously fallible. Most milk is tested for fat content by near infrared reflectance spectroscopy (NIRS). This test performs well compared to wet chemistry procedures (e.g., the Babcock test) when milk fat percentage is in the middle range. Thus, NIRS works well for bulk tank samples. However, it is not as accurate for very high or very low milk fat percentage in individual cows. It also may be affected by somatic cell count or other changes in milk properties [113].

Milk fat (the cream) rises to the top of a milk sample that has not been agitated or homogenized. This can cause an error in any type of milk fat sampling. Bulk tanks must be agitated before sampling for milk fat percentage. Keep in mind that bulk tanks can be agitated too vigorously, which results in butter formation within the tank. This could artificially lower milk fat percentage. Also, milk samples from individual cow samples must be shaken before testing in the lab. Milk fat percentage also varies dramatically from the start to the end of milk out. Thus, milk samples from individual cows must be collected with a proportioning device that meters out a representative portion of the entire milking [114]. Strip samples from cows have no value whatsoever for milk fat testing.

Breed also has a profound effect on milk fat percentage. Normal milk fat percentage for Holstein herds is between about 3.4 and 4.0 percent. Ayrshire and Milking Shorthorn herds have about the same milk fat percentage. Jersey cows have normal milk fat tests between about 4.2 and 5.0 percent. They exhibit the same seasonality of milk fat percentage as Holstein's do. Normal milk fat percentage for Brown Swiss herds is between about 3.6 and 4.2 percent, and for Guernsey herds, it is between 4.0 and 4.8 percent. Milk fat depression is broadly defined as milk fat test below 3.2 percent in Holstein, Ayrshire, and Milking Shorthorn herds, below 3.4 percent for Brown Swiss herds, below 4.0 percent for Guernsey herds, and below 4.2 percent in Jersey herds [115]. Milk fat depression cannot be defined without knowing the days in milk of the cows being evaluated. Herds typically do not have a wide variation in days in milk unless they are seasonally calving. However, individual cows can have quite variable milk fat percentage due to days in milk alone. Days in milk can account for changes in milk fat percentage up to about 0.75 percent, with the lowest milk fat occurring around two months after calving [116].

DHI milk fat tests for the entire herd are determined by testing milk fat percentage and milk volume from each cow. This is usually done for just one daily milking, and only once a month. The milk fat test for the herd is then calculated by a weighted average of the milk fat and milk volume contribution from each cow. Milk fat percentages are adjusted for a.m. or p.m. milking's since the a.m. milking typically has higher volume and lower milk fat percentage [117]. However, these corrections are estimates only and become even less accurate when cows are milked more than twice daily. DHI milk fat test results are useful for looking at trends by days in milk and for variation in milk fat test, but they are not a particularly accurate measure of whole herd milk fat percentage. The milk fat test from the bulk tank is a much more accurate indication of whole herd milk fat percentage. Bulk tank milk fat percentages are also available on a daily or every other day basis. In contrast, DHI milk fat percentages usually represent only one milking per month.

It is interesting to note that the interpretation of milk fat: protein ratios did not appear to change after the basis for milk protein reporting was changed from crude protein to true protein in early 2000 in the US. I do not recommend attempting to interpret milk fat: protein ratios when investigating milk fat depression problems. There are three major causes for cases of confirmed milk fat depression in dairy herds: overfeeding unsaturated fats, Monessen feeding, and SARA. Although fundamentally different, all three share the same end pathway – absorption of excessive amounts of certain trans fatty acids from the small intestine.

CONCLUSION

The results of this study show that FPR is depending greatly on breed, season, and days in milk. Nutritional causes of milk fat depression only become a concern when these three major factors have already been checked and it has been determined that the problem is for real. Estimation of the FPR can be easily observed from test-day records. The decreased milk production means lower income for farmers. Routine observation of F/P ratio in milk possible solution for diagnosing of metabolic disorders in the future as a cheap, non-invasive and eventually fast way of metabolic disorder indication. Also, milk yield has a negative influence on milk fat percentage, Thus, we must modify the ideal range for this ratio in proportion to the potential of domestic cows genetic and the environment. Further research based on larger dataset even entire population of animals is necessary to confirm the results obtained in this study.

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REFERENCES

1. Nielen M, Aarts MG, Jonkers AG, Wensing T, Schukken YH. Evaluation of two cow side tests for the detection of subclinical ketosis in dairy cows. Can Vet J. 1994;35:229-32.

2. Duffield TF, Kelton DF, Leslie KE, Lissemore KD, Lumsden JH. Use of test day milk fat and milk protein to detect subclinical ketosis in dairy cattle in Ontario. Can Vet J. 1997;38:713-18.
3. Geishauser T, Leslie K, Tenhag J, Bashiri A. Evaluation of eight cow-side ketone tests in milk for detection of subclinical ketosis in dairy cows. J Dairy Sci. 2000;83:296-99.
4. Schäfer M, Bethe W. The occurrence of ketosis on our dairy herds. MH VETMED. 1976;31:505-08.
5. Berglund B, Larsson K. Milk ketone-bodies and reproduction performance in postpartum dairy cows. Proceedings of the 5th International Conference on Production Disease in Farm Animal, Uppsala. Sweden. 1983;153-57.
6. Kauppinen K. Prevalence of bovine ketosis in relation to number and stage of lactation. Acta Veterinaria Scandinavica. 1983;24:349-61.
7. Dohoo IR, Martin SW. Subclinical ketosis: Prevalence and associations with production and disease. Can J Comp Med. 1984; 48(1): 1-5. PubMed
8. Andersson L, Emanuelson U. An epidemiological study of hyperketonaemia in Swedish dairy cows. Prev Vet Med. 1985;3: 449-62.
9. Markusfeld O. Periparturient traits in seven high dairy herds. Incidence rates, association with parity, and interrelationships among traits. J Dairy Sci. 1987;70:158-66.
10. Rossow N, Bolduan G. Fat mobilization of the dairy cow book: Metabolic disorders in pets. Gustav-Fischer Verlag Jena Stuttgart. 1994:51-64.
11. Geishauser T, Leslie K, Kelton D, Duffield T. Evaluation of five cow side tests for use with milk to detect subclinical ketosis in dairy cows. J Dairy Sci. 1998;81:438-43.
12. Jorritsma R, Baldee SJC, Schukken YH, Wensing T, Wentink GH. Evaluation of a milk test for detection of subclinical ketosis Vet Quart. 1998;20:108-10.
13. Duffield TF, Lissemore KD, Mcbride BW, Leslie KE. Impact of hyperketonemia in early lactation dairy cows on health and production. J Dairy Sci. 2009;92:571-80.
14. Mcart JA, Nydam DV, Oetzel GR. Epidemiology of subclinical ketosis in early lactation dairy cattle. J Dairy Sci. 2012;95:5056-066.
15. Suthar VS, Canelas-Raposo J, Deniz A, Heuwieser W. Prevalence of subclinical ketosis and relationships with postpartum diseases in European. dairy cows. J Dairy Sci. 2013;95:2925-938.
16. Ospina PA, Mcart JA, Overton TR, Stokol T, Nydam DV. Using nonesterified fatty acids and beta-hydroxybutyrate concentrations during the transition period for herd-level monitoring of increased risk of disease and decreased reproductive and milking performance. Vet Clin North Am Food Anim Pract. 2013;29:387-412.
17. Berge AC, Vertenten G. A field study to determine the prevalence, dairy herd management systems, and fresh cow clinical conditions associated with ketosis in Western European dairy herds. J Dairy Sci. 2014; 97:2145-154.
18. Raboisson D, Mounie M, Khenifar E, Maigne E. The economic impact of subclinical ketosis at the farm level: Tackling the challenge of over-estimation due to multiple interactions. Prev Vet Med. 2015;122:417-25.
19. Seifi HA, Leblanc SJ, Leslie KE, Duffield TF. Metabolic predictors of post-partum disease and culling risk in dairy cattle. Vet J. 2011;188:216-20.
20. Leblanc SJ, Leslie KE, Duffield TF. Metabolic predictors of displaced abomasum in dairy cattle. Dairy Sci. 2005;88:159-70.
21. Amanda M, Zerkel AM, Shanks RD. Field study of displaced abomasum. Illini Dairy. The Online Resource for the Dairy Industry. 2006.
22. Vagts H. The influence of ketosis on udder health and milk quality. Dissertation, Faculty of Veterinary Medicine. FU Berlin. 2000;81:766.
23. Walsh RB, Walton JS, Kelton DF, Leblanc SJ, Leslie KE, Duffield TF. The effect of subclinical ketosis in early lactation on reproductive performance of postpartum dairy cows. J Dairy Sci. 2007;90:2788-96.
24. Eicher R. Stoffwechsel der Milchinhaltsstoffe. 2003.
25. Auldist MJ, Coats S, Rogers GL, McDowell GH. Changes in the composition of milk from healthy and mastitis dairy cows during the lactation cycle. Aus J Exp Agri. 1995;35:427-36.
26. Nielsen NI, Larsen T, Bjerring M, Ingvartsen KL. Quarter health, milking interval, and sampling time during milking affect the concentration of milk constituents. J Dairy Sci. 2005;88:3186-200.
27. De Kruif A, Mansfeld R, Hoedemaker M. Veterinary stock management for dairy cattle. Aufl. Enke Verlag, Stuttgart. 1998;29-474.
28. Rossow N. Nutzung der Ergebnisse der Milchleistungsprüfung für die Fü Stoffwechselkontrolle. 2004.
29. Fürll M. Special examination for ruminants. In: Kraft, W., und U. M. Dürr (Hrsg.): Clinical laboratory diagnostics in veterinary medicine. 6 Aufl Schattauer Verlag Stuttgart NewYork S. 2005;444-74.
30. LKV. The state board of trustees of producer rings for animal finishing in Bavaria. 2003.
31. Reist M, Erdin DK, Von Euw D, Tschumperlin KM, Leuenberger H, Chilliard Y, et al. Estimation of energy balance at the individual and herd level using blood and milk traits in high-yielding dairy cows. J. Dairy Sci. 2002;85:3314-327.
32. Gelfert CC, El-Magragy M, Staufenbiel R. Liver fat content and liver function of cows with left displaces abomasum. World Buiatric Congress, Québec, Canada. 2004;34:108.
33. De Vries MJ, Veerkamp RF. Energy balance of dairy cattle in relation to milk production variables and fertility. J Dairy Sci. 2000;83:62-9.
34. Denis-Robichaud J, Dubuc J, Lefebvre D, DesCôteaux L. Accuracy of milk ketone bodies from flow-injection analysis for the diagnosis of hyperketonemia in dairy cows. J Dairy Sci. 2014;97:3364-370.
35. Eicher R. Evaluation of the metabolic and nutritional situation in dairy herds: Diagnostic use of milk components. Medecin Veterinaire du Quebec. 2004;34:36-38.
36. Gelfert, CC, Staufenbiel R. Early detection of metabolic diseases of dairy cattle by using milk data, body condition and metabolic profiles. 23 World Buiatric Congress Québec Canada. 2004;34:559.
37. Akers RM. Lactation and the mammary gland. Blackwell. 2002.
38. Staufenbiel R, Schröder U. Body condition assessment by ultrasound measurement of the back-fat thickness. Nutztier Spiegel. 2004;14:149-155.
39. Krogh MA, Toft N, Enevoldsen C. Latent class evaluation of a milk test, a urine test, and the fat-to-protein percentage ratio in milk to diagnose ketosis in dairy cows. J Dairy Sci. 2011;94:2360-367.
40. Madouasse A, Huxley JN, Browne WJ, Bradley AJ, Dryden IL, Green MJ. Use of individual cow milk recording data at the start of lactation to predict the calving to conception interval. J Dairy Sci. 2010;93:4677-690.

41. Bionaz M, Loor J, Hurley W. Milk protein synthesis in the lactating mammary gland: Insights from transcriptomics analyses. In W. Hurley (Ed), Milk Protein. New York, USA: InTech. 2012.
42. Gross J, Van Dorland HA, Bruckmaier RM, Schwarz FJ. Performance and metabolic profile of dairy cows during a lactational and deliberately induced negative energy balance with subsequent realimentation. J Dairy Sci. 2011;94:1820-30.
43. Van Knegsel ATM, Van Den Brand H, Dijkstra J, Tamminga S, Kemp B. Effect of dietary energy source on energy balance, production, metabolic disorders and reproduction in lactating dairy cattle. Reproduction Nutri Development. 2005;45:665-88.
44. Yang L, Lopez-Villalobos N, Berry DP, Parkinson T. Phenotypic relationship between milk protein percentage and reproductive performance in three strains of Holstein Fresain cows in Ireland. Proceedings of the New Zealand Society of Animal Production. 2010;70:29-32.
45. Alawneh JI, Stevenson MA, Williamson NB, Lopez-Villalobos N, Otley T. The effect of live weight change on reproductive performance in a seasonally calving, pasture fed dairy herd. Livestock Sci. 2012;145:131-39.
46. Heuer C. Negative energy balance in dairy cows - prediction, consequences and prevention. Thesis, Utrecht University, Faculty of Veterinary Medicine. 2000.
47. Buttchereit N, Stamer E, Junge W, Thaller G. Evaluation of five lactation curve models fitted for fat: protein ratio of milk and daily energy balance. J Dairy Sci. 2010;93:1702-12.
48. Patton J, Kenny DA, Mee JF, O'Mara FP, Wathes DC, Cook M, Murphy JJ. Effect of milking frequency and diet on milk production, energy balance, and reproduction in dairy cows. J Dairy Sci. 2006;89:1478-87.
49. Knop R, Cernescu H. Effects of negative energy balance on reproduction in dairy cows. Faculty of Veterinary Medicine Timisoara. 2009;119:198-205.
50. Zurek E, Foxcroft GR, Kennelly JJ. Metabolic status and interval to first ovulation in postpartum dairy cows. J Dairy Sci. 1995;8:1909-920.
51. Heuer C, Schukken YH, Dobbelaar P. Postpartum body condition score and results from the first test day milk as predictors of disease, fertility, yield, and culling in commercial dairy herds. J. Dairy Sci. 1999;82:295-304.
52. Klein MS, Buttchereit N, Miemczyk SP, Immervoll AK, Louis C, Wiedemann S, et al. NMR Metabolomic analysis of dairy cows reveals milk glycerophosphocholine to phosphocholine ratio as prognostic biomarker for risk of ketosis. J. Proteome Res. 2012;11:1373-381.
53. Tetens J, Seidenspinner T, Buttchereit N, Thaller G. Whole-genome association study for energy balance and fat/protein ratio in German Holstein bull dams. Anim Genet. 2013;44:1-8.
54. Gruber L, Steinwender R, Baumgartner W. Influence of basic feed quality and concentrate level on the performance, metabolism and economy of cows of the Fleckvieh and Holstein Frisian breeds. Report on the 22nd animal breeding conference BAL Gumpenstein. 1995;9-10:1-49.
55. Buttchereit N, Stamer E, Junge W, Thaller G. Model evaluation and estimation of genetic parameters for energy balance and related traits in dairy cows. Züchtungskunde. 2012;84:74-89.
56. Rossow N, Staufenbiel B. Control of energy and fat metabolism in high-performance cows. 1991;46:735-37.
57. Grieve DG, Korver S, Rijpkema YS, Hof G. Relationship between milk composition and some nutritional parameters in early lactation. Livestock Prod Sci. 1986;14:239-54.
58. Redetzky R. Biochemical blood profile, milk ingredients and milk volume output as criteria for the lactation-accompanying assessment of the state of health of high-performing HF cows in tethering, dissertation. Ti Ho Hannover. 2000;34-41.
59. Geishauer T, Leslie K, Duffield T, Edge V. The relationship of milk parameters during the first milk test to subsequent determination of abomasal shift in dairy cows, Berl. Münch. Tierärztl. Wschr. 1999;112:1-4.
60. Hagert C. Continuous control of the energy and protein supply of the dairy cow during lactation based on the concentration of acetone, urea, protein and fat in the milk, dissertation. Faculty of Veterinary Medicine University of Munich. 1992.
61. Hagmüller W. Studies on brown cattle in the Innviertel region of Upper Austria - metabolic profiles of the first 100 days of lactation, dissertation. UniKlinik of the VetMed Uni Wien Ti Ho Hannover. 2002;1-4:58-72.
62. Heuer C, Metzner M, Schukken Y. Influences of lactation level, milk fat content and age of dairy cows on the feeding-related evaluation of data from the milk performance test, Tierärztl. Umsch. 1996;51:84-95.
63. Institute for Animal Production Dummerstorf. Milk parameters, State Research Center for Agriculture and Fisheries Mecklenburg Western Pomerania, 2001.
64. Miettinen Pv, Setälä Jj. Relationship between subclinical ketosis, milk produktion fertility in Finnish dairy cattle, Preventive Veterinary Medicine. 1993;17:1-8.
65. Reist M. Characterization of high yielding dairy cows with regard to stability of metabolism and reproduction, characterization of cows with high milk yields in terms of metabolic stability and fertility, Dissertation, ETH, Zürich, 2001; 174.
66. Steen A, Osteras O, Gronstol H. Evaluation of Additional Acetone and Urea Analyses, and of the Fat-Lactose-Quotient in Cow Milk samples in the Herd Recording System in Norway. J Vet Med. 1996;43:181-91.
67. Wolter W, Kloppert B, Casteneda H, Zschök M. Cattle mastitis - A course book, Hessen State Examination Office, Gießen. 1999.
68. Vagts H. The influence of ketosis on udder health and milk quality. Praktischer Tierarzt.2000;81:766.
69. García CAC, Montiel RLA, Borderas TF, Girard V. Relationship between β-hydroxybutyrate and the fat: protein ratio of milk during early lactation in dairy cows. Arch Med Vet. 2015;47:21-25.
70. Čejna V, Chládek G. The importance of monitoring changes in milk fat to milk protein ratio in Holstein cows during lactation. J. Cent. Eur. Agric. 2015; 6: 539-546. Direct Link
71. Paura L, Jonkus D, Ruska D. Evaluation of the milk fat to protein ratio and fertility traits in Latvian brown and Holstein dairy cows. Acta Argiculturae Slovenica. 2012; 3: 155-159.
72. De Boer G, Trenkle A, Young JW. Glucagon, iInsulin, growth hormone and some blood metabolites during energy restriction ketonemia of lactating cows. J Dairy Sci. 1985;68:326–37.
73. Drackley JK, Richard MJ, Beitz DC, Young JW. Metabolic changes in dairy cows with ketonemia in response to feed restriction and dietary 1,3-Butanediol. J Dairy Sci. 1992;75:1622-34. PubMed
74. Dirksen G, Hagert-Theen C, Alexander-Katz M, Berger A. Monitoring of dairy cows for metabolic imbalances during high lactation by means of milk parameters. I. Daily milk yield, fat and protein concentrations, fat-protein-quotient and urea concentration. Tierärztliche Rundschau. 1997;52:476-484.
75. Rossow N, Staufenbiel B, Jakobi U. Use of milk ingredients for metabolism monitoring in dairy cows. Monatshefte Veterinärmedizin. 1990;45:686-690.
76. Gravert HO. Indicators for assessing the energy balance of the dairy cow. Monatshefte Veterinärmedizin. 1991;46:536-37.

77. Kümel-Möllering M, Rossow N. Use of milk performance test data to indirectly assess the metabolic status of dairy cows. Monatshefte Veterinärmedizin. 1994;49:115-19.
78. Toni F, Vincenti L, Grigoletto L, Ricci A, Schukken YH. Early lactation ratio of fat and protein percentage in milk is associated with health, milk production, and survival. J Dairy Sci. 2011;94:1772-783.
79. Vanholder T, Papen J, Bemers R, Vertenten G, Berge ACB. Risk factors for subclinical and clinical ketosis and association with production parameters in dairy cows in the Netherlands. J Dairy Sci. 2014;98:880-88.
80. Vlček M, Candrák J, Kasarda R. Fat-to-protein ratio: evaluation of metabolic disorders and milk yield. 24th Int. Symp. "Animal Science Days", Ptuj, Slovenia, Cobiss: 1.08. Agris category code: L73. 2016;5:76-9.
81. Duffield T, Bagg R. Herd level indicators for the prediction of high-risk dairy herds for subclinical ketosis. 2002;35:175-76.
82. Geishauser T, Leslie K, Duffield T, Edge V. Fat/protein ratio in first DHI test milk as test for displaced abomasum in dairy cows. Zentralbl Veterinarmed A. 1997;44:265-70.
83. Haas D, Hofírek B. The diagnostic importance of milk components for a human and cows' health, CUA Prague. Proceedings of contributions Milk day. 2004,26-29.
84. Duffield T. Subclinical ketosis in lactating dairy cattle. Vet Clin North Am Food Anim Pract. 2000;16:231-53.
85. Richardt W. Milk composition as an indicator of nutrition and health. The Breeding. 2004;11:26-27.
86. Mahlkow-Nerge, K. The significance of the characteristic value lactic fat-protein quotient. Nutztierpraxis aktuell. 2009;1:50-52.
87. Podpečan O, Mrkun J, Zrimšek P. Diagnostic evaluation of fat to protein ratio in prolonged calving to conception intervals using receiver operating characteristic analyses. Reprod Domest Anim. 43:249-54.
88. Spohr M, Beening J, Scholz H. Information from cattle milk to check feeding and health. Praktischer Tierarzt Coll Vet XXIII. 1992;52-56.
89. Kraft W, Dürr UM. Clinical laboratory diagnostics in veterinary medicine. Book Schattauer Verlag. 1997;368:275-77.
90. Kraft W, Dürr UM. Clinical laboratory diagnostics in veterinary medicine. Book. 6. Auflage, Schattauer Verlag Stuttgart/New York, USA. 2005.
91. Jenkins NT, Peña G, Risco C, Barbosa CC, Vieira-Neto A, Galvão KN. Utility of inline milk fat and protein ratio to diagnose subclinical ketosis and to assign propylene glycol treatment in lactating dairy cows. Can Vet J. 2015;56:850-4.
92. Staufenbiel R. Ketose (Azetonämie, Azetonurie) der Milchkuh; 2014.
93. Gruber L, Urdl M, Obritzhauser W, Schauer A, Häusler J. Energy and nutrient supply of dairy cows in the dry period and at start of lactation: Production data and metabolic parameters. Tagungsband 42 Viehwirtschaftliche Fachtagung. 2015;978:95-126.
94. Palmquist DL, Beaulieu AD, Barbano AD. Feed and animal factors influencing milk fat composition. J Dairy Sci. 1993; 76:1753-771.
95. Eastridge ML. Guidelines for low forage diets. Proceedings Tri-State Dairy Nutrition Conference. 2000; April 18-19, The Ohio State University, Columbus. 2000.
96. Stoop WM, Bovenhuis H, Heck JML, Van Arendonk JAM. Effect of lactation stage and energy status on milk fat composition of Holstein-Friesian cows. J. Dairy Sci. 2009;92:4
97. Bastiaansen J, Bovenhuis H, Wijga S, Mc Parland S, Wall E, Strandberg E, et al. Genome Wide Association Study for Milk and Fat / Protein Ratio in Dairy Cattle. 2010.
98. Brade W, Hamann H, Brade E, Distl O. Studies on the loss of first calves in Saxony. Züchtungskunde. 2008;80:127-36.
99. Römer A. Studies on the service life of German Holstein cows. Züchtungskunde. 2011;83:8-20.
100. Wangler A, Blum E, Böttcher I, Sanftleben P. Life performance and useful life of dairy cows from the perspective of efficient milk production. Züchtungskunde. 2009;81:341-60.
101. Mertens DR. Creating a system for meeting the fiber requirements of dairy cows. J Dairy Sci.1997;80:1463-81.
102. Oetzel GR. Application of forage particle length determination in dairy practice. Compend. Contin. Educ. Pract. Vet. 2001; 23: 30-38.
103. Kuterovac K, Balaš S, Gantner V, Jovanovac S, Dakić A. Evaluation of nutritional status of dairy cows based on milk results. Ital. J Anim. Sci. 2005;4:33-35.
104. Overton TR, Lock AL, Perfield II JW, Bauman DE. Troubleshooting milk fat challenges on commercial dairy farms. In Proc Animal Nutrition Association of Canada Eastern Nutrition Conf. 2006;127-137.
105. Kadyere CT, Murphy MR, Silanikove N, Maltz E. Heat stress in lactating dairy cows: A review. Livestock Prod Sci. 2002;77:59-91.
106. Garrett R. Oetzel, DVM. Update on milk fat depression in dairy herds. Western Dairy News. 2012.
107. Smith JW, Ely LO, Graves WM, Gilson WD. Effect of milking frequency on DHI performance measures. J Dairy Sci. 2002;85:3526-33.
108. Allen DB, DePeters EJ, Laben RC. Three times a day milking: Effects on milk production, reproductive efficiency, and udder health. J Dairy Sci. 1986;69:1441-46.
109. Amos HE, Kiser T, Loewenstein M. Influence of milking frequency on productive and reproductive efficiencies of dairy cows. J Dairy Sci. 1985;68:732-39.
110. DePeters EJ, Smith NE, Acedo-Rico J. Three- or two-times daily milking of older cows and first lactation cows for entire lactations. J Dairy Sci. 1985;68:123-32.
111. McNamara S, Murphy JJ, O'Mara FP, Rath M, Mee JF. Effect of milking frequency in early lactation on energy metabolism, milk production and reproductive performance of dairy cows. Livest Sci. 2008;117:70-78.
112. Remond R, Pomies D, Julien C, Guinard-Flament J. Performance of dairy cows milked twice daily at contrasting intervals. Animal, 2009;3:1463-71.
113. Garrett R, Oetzel, DVM. Subacute Ruminal Acidosis in Dairy Herds: Physiology, Pathophysiology, Milk Fat Responses, and Nutritional Management. American Association of Bovine Practitioners 40th Annual Conference, September 17, 2007; Vancouver, BC, Canada.
114. Fouz R, Yus E, Sanjuán ML, Diéguez FJ. Effect of the sampling device on fat and protein variation in cow milk samples obtained for official milk recording. J Dairy Sci. 2009;92:4914-918.
115. Eastridge ML. Variation in milk fat of fresh cows. Tri-State Dairy Nutrition Conference. The Ohio State University, Columbus. 2012;59-65.
116. Bremmer D. Monitoring subclinical ketosis in transition dairy cows. Vita Plus Corp., Madison, WI 2012.
117. Kirovski D. Evaluation of energy status of dairy cows using milk fat, protein and urea concentrations. Mac. Vet. Rev. 2011;34:39-45.