דו"ח דיווח מדעי      הופק בתאריך: 03.08.09
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קוד זיהוי : 459-4247-08

נושא המחקר: ניצול נתוני הרכב חלב מקוון לשיפור ממשק פרת החלב:
הערכת צריכת מזון וייעול הייצור על פי רכיבים

סוג דו"ח : דו'ח מסכם


חוקר ראשי : מלץ אפרים    מינהל המחקר החקלאי

חוקרים משניים: שמילוביץ זאב    מינהל המחקר החקלאי
הלחמי אילן    מינהל המחקר החקלאי
אנטלר אהרון    מינהל המחקר החקלאי



מקורות מימון עבורם מיועד הדו"ח:
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המועצה לענף החלב    20,000



תקציר הדו"ח:
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בשנה הראשונה נבחן האב-טיפוס של מד הרכב חלב מקוון שפותח ע"י אנשי המכון להנדסה חקלאית וחברת צ.ח.מ. אפיקים. הבדיקות הראו שקיים היסט בדיוק התוצאות ונבנתה ורסיה משופרת של מדי הרכב החלב.
בעיקבות העבודה והמסקנות שהוסקו ב- שנת העבודה הראשונה הורכבו ברפת בית דגן ורסיה מתקדמת של מדי הרכב חלב במכון החליבה. נערכה סידרת בדיקות הרכב חלב על מנת לבדוק אם תוקנו הליקויים של הורסיה הקודמת במשך 5 ימים ב- 15 חליבות רצופות. המכשיר עמד בתחומי גבולות הדיוק שנקבעו ללא היסט.
בהמשך נעשה ניסוי לניצול נתוני הרכב מקוון להקצאת מזון מרוכז (מ"מ) לפרות על-פי בצועיהן במגמה לצמצם צריכת חמר יבש מחד ולהעלות את איכות החלב בטנק מאידך. הדבר נעשה ע"י "הוצאת" המזון המרוכז מהבליל והקצאתו, לכל פרה באופן אינדיבידואלי על פי בצועים, במאביסים פרטניים מבוקרי מחשב (מפמ"מ). הקריטריונים שנקבעו לרמת ההקצאה היו אחוז השומן בחלב שחושב כממוצע רץ של 3 ימים עוקבים ונמדד לכל פרה בכל חליבה ע"י מד הרכב חלב של חברת צח"מ אפיקים. התוצאות הראו שמד הרכב החלב בנוסף לחיישנים הקיימים (מד חלב, מאזנים אלקטרונים לשקילת הפרות ביציאה ממכון החליבה), תוכנת הניהול וה- מפמ"מ ניתן ליישם ממשק הזנה מדייק המבוסס על ביצועים בהתאם למדיניות כלכלית.
בשנה השלישית חזרנו על הניסוי שבוצע בשנה השנייה אך הפעם עם שני רכיבי מזון מרוכז נפרדים; אנרגיה (תערובת מכופתתת גרעינים) וחלבון (תערובת מכופתתת כוספת סויה).
ההוצאה העיקרית ברפת החלב היא המזון לפרות ומתוכו יקרות ביותר התערובות של המזון המרוכז. הקצאה אינדיבידואלית של מזונות מרוכזים בעזרת מפמ"מ מאפשרת הקצאה על פי ביצועים מחד והיעדים הכלכליים של הרפת מאידך. זמינותו של מד הרכב חלב מקוון סגר פער משמעותי ביכולת היישום של גישה זאת היות ומעתה ניתן לצפות בתגובות הביצועים של הפרות לא רק לגבי כמות החלב אלא גם לגבי הרכבו שהוא היעד העיקרי להקצאת מזון מרוכז על פי ביצועים.
מטרת העבודה בניסוי זה הייתה לשלב את מד החלב המקוון במערכת קבלת ההחלטות להקצאת מ"מ (אנרגי וחלבון) שתתבצעה בתדירות גבוה לקבלת חלב בהרכב שומן רצוי.
23 פרות הואבסו בבליל באבוס שכלל אך ורק מזונות גסים ותוספת מינרלים וויטמינים. כל המזון המרוכז (אנרגיה וחלבון) שכלל אף הוא תוספת מינרלים וויטמינים הוקצה ב מפמ"מ. הקצאת המזונות המרוכזים לכל הפרות נעשתה על פי קריטריונים זהים פרט להבדל שלמחצית מהפרות (12 פרות - קבוצה 1) ההחלטות נעשו על סמך הרכב חלב שהתקבל

מקורות מימון עבורם מיועד הדו"ח:

תקציר הדו"ח:

בביקורת חודשית ושאר הפרות (11 פרות - קבוצה 2) הוקצה המ"מ על פי הרכב חלב מקוון. כל הפרות שהו באותה קבוצה והשתמשו באותם מאביסים באותה שיטה. הן חולקו לשתי הקבוצות על פי זמן המלטה ומספר תחלובה.
התוצאות הראו שהפרות בקבוצה 2 הניבו פחות חלב אך יותר חמ"ש וצרכו יחסית פחות מ"מ מהפרות בקבוצה 1. בנוסף הייתה לפרות בקבוצה 2 צריכת ח"י גבוה יותר והם אבדו פחות משקל לאורך כל תקופת המדידה.

חתימות ואישורים:

| חוקר ראשי | מנהל המחלקה | מנהל המכון | אמרכלות | היחידה לתכניות עבודה ותקציב | תאריך |
|---|---|---|---|---|---|

דו"ח מסכם

תוכנית 459-4247-08 ניצול הרכב חלב מקוון לשיפור ממשק פרת החלב

מגישים

אפרים מלץ, אהרון אנטלר, אילן הלחמי, זאב שמילוביץ

תקציר

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התוצאות הראו שהפרות בקבוצה 2 הניבו פחות חלב אך יותר חמ"ש וצרכו יחסית פחות מ"מ מהפרות בקבוצה 1.בנוסף הייתה לפרות בקבוצה 2 צריכת ח"י גבוה יותר והם אבדו פחות משקל לאורך כל תקופת המדידה.

תוצאות העבודה בשנה השלישית פורסם ב:

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# Precision concentrate rationing to the dairy cow using on-line daily milk composition sensor, milk yield and body weight

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**Abstract**
The main expense in the dairy operation is food. Individual feeding enables tailoring a precise ration for each cow. New technologies had improved capabilities to ration concentrates individually. However, the absence of an on-line milk composition analyzer restricts the efficient exploitation of these technologies. This hurdle was recently overcome. A new sensor (Afilab$^{TM}$) was developed, which measures milk composition (fat, protein and lactose and gives indication of blood and somatic cell count - SCC) for each cow every milking was developed. These results in the acquisition of milk component data as milk yield and body weight data.
The objective of this study was to incorporate the on-line milk composition data into the concentrates allocation decision making in order to improve cow performance under a defined economical policy of a commercial dairy by using dual channel computer controlled concentrates dispensers.
23 multiparous cows were fed forages in the common trough and all the concentrates through dual channel computer controlled self feeders. Concentrates were rationed individually according to performance. The NRC 2001 formula for predicting dry matter intake (DMI) of individual cow was applied to calculate protein and ration density. For 11 cows daily concentrates were allocated by using daily milk composition data and for the rest of the cows milk composition recorded by periodical milk test was used.
On average milk yield was lower but 4% fat corrected milk was significantly higher and relatively less concentrates were allocated to the cows for which decisions were done according to on-line milk composition data. In addition, they had a higher dry matter intake and lost less weight during transition time. The periodical milk test failed to provide the needed information regarding milk fat decrease during transition time which led to rationing concentrates in a level that most likely caused a greater decrease in milk fat during this period.

Key words: fat, protein, lactose, body weight, transition time, lactation, dairy

## Introduction
The core of precision livestock farming is precision management of the individual animal out of which precision feeding may be the most significant issue. The dairy industry undergoes structural and economical changes in the last decades. The number of farms is declining while the average number of animals in each farm is increasing. This calls for improved management that exploits the opportunities offered by new technologies for precision dairy farming that will improve profitability on one hand and animal welfare on the other. The main expense in the dairy operation is food out of which concentrates is the larger part. With the global rise in prices of feedstuff, the economical importance of individual feeding is increasing. Individual feeding enables tailoring a precise ration for each individual cow according to its characteristic nutritional needs. This feeding method is particularly important when concentrate supplementation is needed (e.g. pasture management, robotic milking, fresh cows or other non homogenous groups). Individual concentrates supplementation is on the "agenda" since the first

computer controlled self feeders (CCSF) for concentrates supplementation were introduced to the industry in the late seventies early eighties of the last century. The possibilities offered by this technology attracted the dairy industry and they went into use ahead of proper research. However, the first controlled trials of supplementing cows with concentrates by CCSF using milk production as the indication for level of supplementation indicated that more information, in addition, to milk yield (MY) is required in order to exploit efficiently the possibilities offered by this technology (Maltz et al. 1991, 1992, Spahr et al. 1993). The body weight (BW) of the dairy cow was indicated as a crucial variable for successful implementation of precision concentrates rationing either to characterize the cow's potential or as, together with milk yield changes, characterizing the energetic and physiological status of the cow for decision making regarding concentrates supplementation (Maltz et al. 1991, 1992, Maltz and Metz 1994, Maltz et al. 1997, Maltz 1997, Spahr et al. 1993,). This led to the development of a walk through weighing system (Peiper et al. 1993) which is now an off the shelf commercial sensor in the dairy industry. The on line BW data provided another crucial point for precision dairy feeding which is the daily food intake of the individual cow. Individual daily food intake can be measured in research farms (even under commercial dairy farm conditions Halachmi et al. 1998) but practically it is not possible in the day-to-day dairy operation which forces us to use models to make accurate concentrates rationing. The on-line real-time BW data provided a crucial component in formulating dry matter intake (DMI) of the dairy cow that is based on available (i.e. time after calving, periodical milk composition) and measurable (i.e. MY and BW) individual performance data (Halachmi et al. 1997, 2004, NRC 2001). This (i.e. frequent BW data and DMI) significantly improved precision concentrates (energy and protein) supplementation (Maltz et al. 2004, 2005). Still, one crucial piece of information was missing. This is on line milk composition (MC), mainly milk fat (MF) that contributes most of the energy excreted in milk. This obstacle was overcome recently. A new sensor that measures milk composition was developed (Afilab™) by S.A.E. Afikim, Kibbutz Afikim, Israel, and The Institute of Agricultural Engineering, A.R.O, The Volcani Center, Israel. The Afilab™ is a novel device that performs real-time analysis of individual cow milk solids (fat, protein and lactose) and gives indication of blood and SCC. The technology is based on spectroscopy, therefore it does not interfere with milk flow through the line nor does it alter the milk in any way. An Afilab™ device can be installed at each milking stall and analyzes each individual cow's milk at every milking. These results in the acquisition of milk component data within the same configuration and time frame as milk weight data measured by the electronic milk meter (Katz et al. 2007, Arazi et al. 2008). This is the first trial ever were daily automatically collected on line milk composition data were incorporated into a concentrates allocation decision making.
The objective of this study was to incorporate the on line milk composition data into the concentrates allocation decision making in order to improve cow performance under a defined economical policy of a commercial dairy by using duel channel CCSF. Namely to improve 4% fat corrected milk (4% FCM) and economize on concentrates consumption.

**Materials and methods**

The study was performed in the experimental dairy of the Volcani Center on Israeli Holstein cows milked thrice daily at 8 h intervals.
The facilities and settings to execute precision concentrates feeding in this study were:

a) Sensors: Milk meters, milk composition analyzers walk-through scales positioned on the outlet path from the milking parlor.
b) Data acquisition: daily MY, MC, BW, concentrates consumption (energy, and protein), visits to CCSF. Once a month, milk composition by periodical milk tests.

c) On-line data analysis and modeling: stage of lactation, DMI, ration energy and protein contents.
d) Individual concentrates allocations based on a general strategy in accordance with actual performance.
e) Executing the concentrates allocation decision: dual channel CCSF that distributed the two kinds (energy and protein) of pelleted concentrates, separately in each channel.

Multiparous cows were divided into one of two groups according to lactation number, and calving date. Both groups were housed in the same pen and fed forage of 1.550 Mcal/kgDM net energy for lactation (NEL) in the feeding lane. All concentrates (energy and protein) were fed through CCSF. The concentrates supplementation strategy for both groups was as follows: Until peak production concentrates were allocated to generate a calculated ration density of 1.765 Mcal/kgDM NEL. For protein, concentrates were allocated to generate a calculated ration density of 28% of DM after calving reducing it gradually to 17% when reaching maximal calculated DMI. As a precaution, the energy and protein concentrates were allocated for all cows by calculating it for fixed DMI amounts: 10 kg/d for days 1-3, 12 kg/d for days 4-5, 13 kg/d for days 6-7, 16 kg/d for days 8-9, 18 kg/d for day 10. After day 10, supplementation strategy was changed in order to economize on concentrates by a strategy to encourage milk production of more than 3% fat and reduce supplementation to cows that failed to do so. The upper limit of concentrates supplementation was to ration concentrates that generate calculated ration density of 1.800 Mcal/kgDM NEL. The lower limit was 1.600 Mcal/kgDM NEL. The only difference between the two groups was that for one group (GR1) the concentrates rationing decision were taken using milk composition measured once a month in the routine periodical milk test and for the second group (GR2) the daily milk composition data provided by the Afilab$^{TM}$ were used for the same purpose. Until the first milk test, for each cow in GR1 the value of 4.0 % fat was used to calculate DMI and ration concentrates. This value was selected out of our experience (see results and discussion). The response of cows in GR1 was checked every milk test and in GR2 3-4 days after concentrates allocation decision. If the feedback was positive (either way increase or decrease of concentrates allocation) the concentrates allocation continued to change in the same direction, if response was "no change" or negative, concentrates allocation was taken one step back. Decreasing concentrates allocation was never done in steps greater than 1 kg every two days.

The daily concentrates allocation was dispensed by the CCSF in 6 time-scaled "feeding windows" (FW) in equal amount. Three FWs "opened" at the hours timed to return from milking, and 3 FWs opened between these hours to form 6 FWs of about 4 h each. Amount not consumed in one feeding window was transferred to the next 6 FWs in equal portions. The CCSF, operating, calibrating, controlling, and recording software and all other sensors and equipment used, were the product of S.A.E. Afikim (Kibbutz Afikim, Israel). The cows were watched closely after calving, and all of them started to use the CCSF within 2 days after calving.

The CCSF were checked daily for accumulating leftovers and calibrated weekly and every time the containers were filled (usually once every 2-4 weeks) with a new batch of concentrates, to give about 300 g/min (± 20g) of both concentrates (energy and protein) together. Cows could enter each CCSF and receive their concentrates allocations. There was no preference to any of the two CCSF (results not shown).

The decisions for concentrates allocation were done twice a week using 3 days running average data of all measured and calculated variables. The DMI was calculated daily from daily MY and BW and periodical milk composition (GR1) and daily milk composition (GR2), by a built-in model based on NRC (2001) and Halachmi et al. (2004). Concentrates allocation decisions were taken using the following equations:

$$\text{Protein} = [(DMI - (DMe+DMp)] * P_{(For)} + DM_{(e)} * P_{(e)} + DM_{(p)} * P_{(p)} \quad (1)$$
$$\%\text{protein} = \text{Protein}/DMI*100 \quad (2)$$
$$NEL_{(Ration)} = [(DMI- (DMe+DMp)]* E_{(For)}+E* DMe* E_{(e)}+ DMp * E_{(P)} \quad (3)$$
$$NEL = NEL_{(Ration)}/DMI \quad (4)$$

Where:

Protein (kg) – amount of protein in the daily full ration

DMI (kg) – model calculated dry matter intake (NRC 2001, Halachmi et al. 2004)

$DM_{(e)}$(kg) – dry matter of energy concentrates allocated daily. Calculated from the amount allocated daily and the measured moisture content.

$DM_{(p)}$(kg) - dry matter of protein concentrates allocated daily. Calculated from the amount allocated daily and the measured moisture content.

$P_{(For)}$(kg) – amount of protein in 1 kg forage DM

$P_{(e)}$(kg) – amount of protein in 1 kg $DM_{(e)}$

$P_{(p)}$(kg) – amount of protein in 1 kg $DM_{(p)}$

%protein (%) – percent of protein in the daily full ration starting 28% and gradually reduced to 17% of DMI as DMI increases towards its peak.

$NEL_{(Ration)}$(Mcal) – total calories in the daily ration.

$E_{(For)}$(Mcal) – amount of calories I 1 kg forage

$E_{(e)}$ - amount of calories in 1 kg $DM_{(e)}$

$E_{(P)}$ - amount of calories in 1 kg $DM_{(p)}$

NEL – Mcal/kgDM NEL

After $DM_{(e)}$ and $DM_{(p)}$ were calculated, their combined value was checked (equation [3]) not to exceed 35% Of DMI.

$$\%Con. = (DMe+DMp)/DMI*100 \quad (5)$$

Where:

%Con is the percentage of daily allocated DMe+DMp in daily calculated DMI.

The trial was carried out for the first 100 days of lactation, 12 cows in GR1 and 11cows in GR2. The daily averages of group performance measured and calculated data of the two groups were compared by student paired t-test.

**Results and discussion**

Table 1. summarizes the measured and calculated performance variables of the two groups. It can be seen that despite a lower MY, Gr2 produced more 4% FCM than GR1 due to 0.21% higher daily average of milk fat content. This was probably achieved through a more efficient concentrates rationing when using the daily milk fat data rather then the periodical ones. This led in general to a restriction in concentrates allocation that was compensated by a higher forage consumption leading to a 1 kg daily increase in DMI. Higher forage consumption is probably the reason for the average higher milk fat (Maltz et al. 1991, 1992. Spahr et al. 1993). The outcome of this is an improved ratio of concentrate allocation to 4% FCM production of about 3.5% a day. Assuming an average concentrates consumption of 14 kg/day/cow, then, for 300 lactation days there will be a saving of about 147 kg per cow while reaching improved milk production. Although there was no attempt to effect milk protein in this study the results show also an improvement in milk protein (and also lactose) for cows that were allocated concentrates using daily milk composition data rather then periodical ones (Table 1). Improved protein production increases profitability even more when milk pricing included milk protein. This is the outcome of both, encouraging production of cows with favorable milk composition and either increasing milk fat by reducing concentrates supplementation or depressing production (at least saving

concentrates) of cows with low milk fat. To depress production of cows with unfavorable milk composition is economically significant under milk quota condition when milk pricing includes its composition.

Table 1. Daily milk yield, 4% FCM yield, concentrates allocation, dry matter intake (DMI) and milk composition (fat, protein and lactose) of 12 cows in group 1 (GR1) for which concentrates were allocated using milk fat of periodical routine milk test sampling (once a month) and 11 cow in group 2 (GR2) for which concentrates were rationed using daily milk fat data provided by the new sensor (Afilab™). In both groups concentrates were rationed twice a week.

| | GR1 | GR2 | P |
|---|---|---|---|
| Milk yield (kg) | 47.5 ± 6.8 | 46.0 ± 6.3 | 0.001 |
| 4% FCM yield (kg) | 40.8 ± 3.9 | 41.7 ± 5.0 | 0.01 |
| Concentrates allocation (kg) | 13.9 ± 1.9 | 13.7 ± 1.8 | 0.001 |
| DMI (kg) | 22.9 ± 3.8 | 23.9 ± 4.5 | 0.001 |
| Milk fat (%) | 3.12 ± 0.63 | 3.23 ± 0.53 | 0.001 |
| Milk protein (%) | 2.83 ± 0.34 | 2.91 ± 0.33 | 0.001 |
| Milk lactose (%) | 4.96 ± 0.26 | 5.00 ± 0.26 | 0.001 |

Another outcome of the concentrates rationing according to daily milk composition data was the BW changes of the cows especially during transition time (Fig 1.).

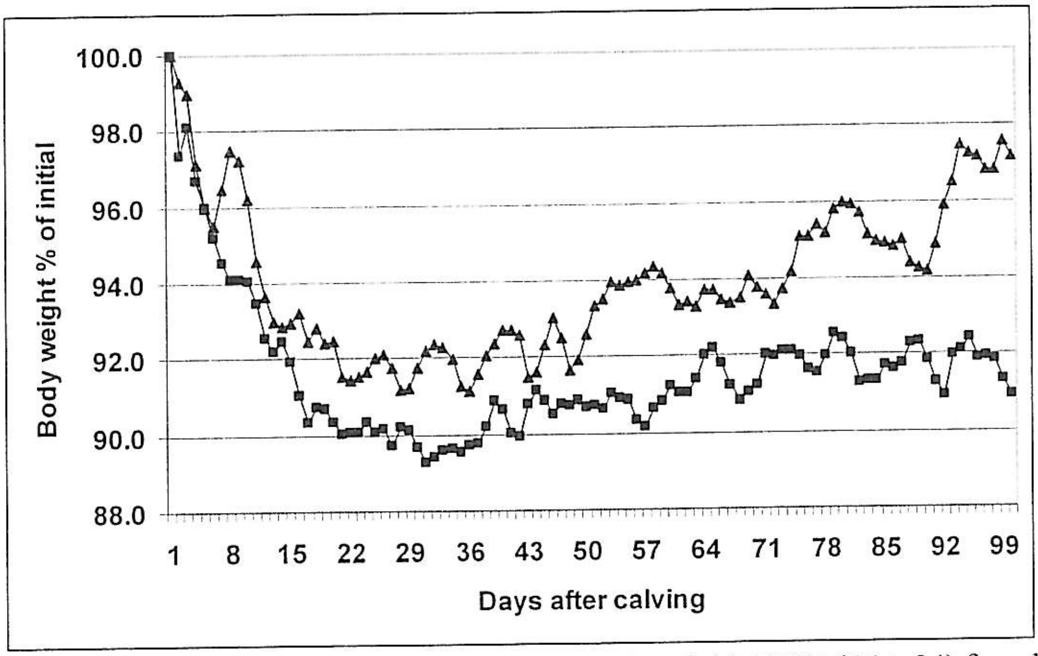


Figure 1. Average daily body weight of 12 cows in group 1 (■ – initial BW 647 ± 34) for which concentrates were allocated using milk fat of periodical routine milk test sampling (once a month) and 11 cow in group 2 (▲ – initial BW 678 ± 89) for which concentrates were rationed using daily milk fat data provided by the new sensor (Afilab™). In both groups concentrates were rationed twice a week. The Gr2 cows lost less weight during transition time and gained weight more rapidly after nadir BW compared to those of GR1.

The advantage of concentrates allocation decision making based on daily milk fat data is presented in Fig 2. Out of the four cows for which periodical (milk test) and daily (Afilab™) milk fat data are presented, only for one (cow 2703) the periodical milk fat is representing the physiological status of the cow and even this is only about 20 days after calving. For all other cows the periodical milk test misses a substantial amount of the data. For cows 2823 and 2713 the first 45 and 75 days respectively in lactation are diverted (regarding milk fat content) because of the rapid change in milk fat during transition time that the periodical milk test is unable to follow. In cow 2731 it is probably an error in sampling that causes the big difference between the periodical and daily milk composition at the very same day that the milk test was performed.

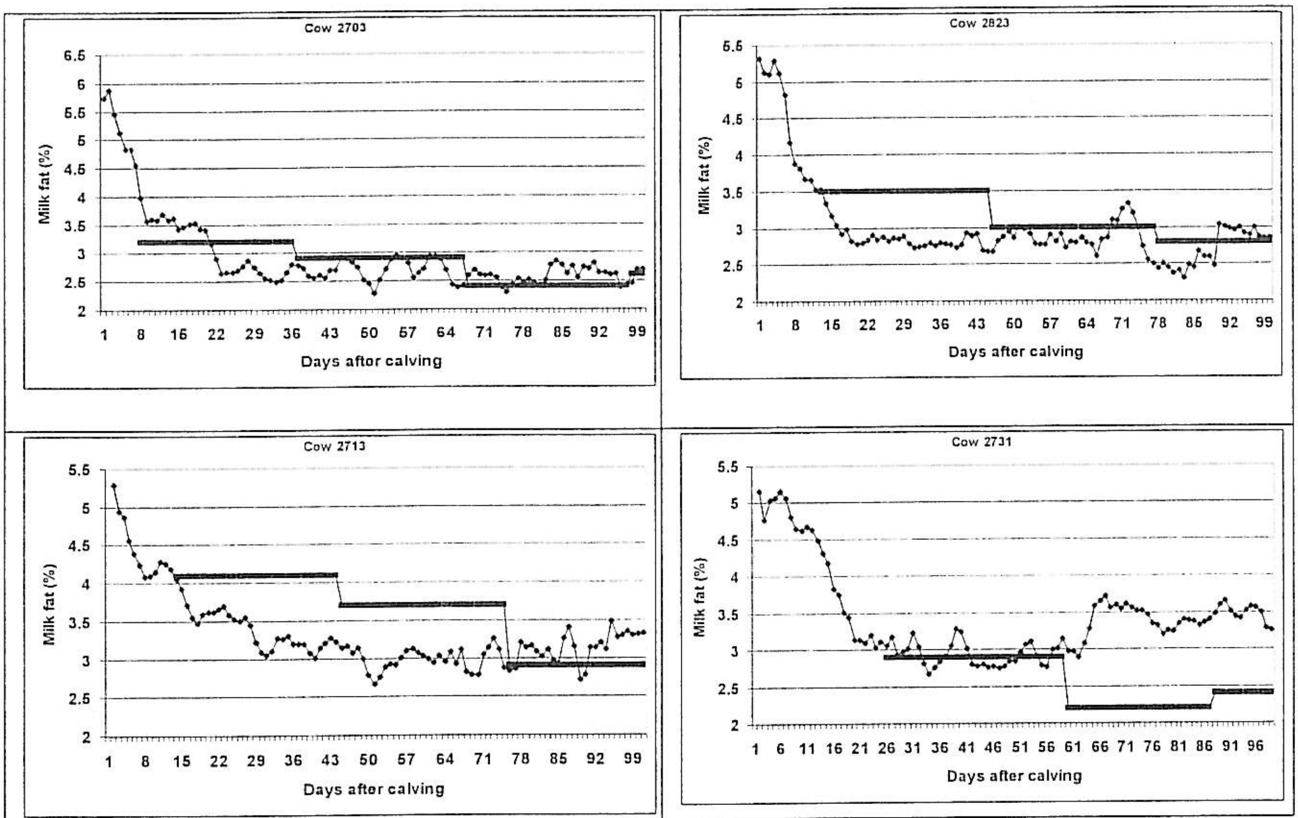


Figure 2. Four cows demonstrating the difference in milk fat values achieved through periodical milk test (■) were one measurement dictates to relay on the same value for about a month until next milk test, and data achieved daily (3 days running average) by the milk composition sensor (▲) were daily and periodical changes are available.

## Conclusions

The on-line milk composition analyzer is a big leap towards precision dairy feeding. It is very likely that when total milk energy that can be calculated from the milk components (not only fat) will be used for concentrates allocation decision making, the physiological and economical results can be improved. It can be concluded that the availability of on line performance data (MY, BW, MC), proper physiological models (based on these data) and technological means to respond physiologically and economically to performance (CCSF), brings precision feeding of the dairy cow within our reach.

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