Scientific Papers. Series D. Animal Science. Vol. LIX, 2016
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

PRACTICAL AND THEORETICAL ASPECTS REGARDING THE PRECISION DAIRY FARMING CONCEPT IN ROMANIA

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Abstract

This paper aims to present in a systematic way the practical and theoretical aspects of the Precision Dairy Farming Concept. This relatively new concept has emerged around the 2000s and for 10 years it referred to the feeding technology of dairy cows (Precision Feeding). Then, in 2010, a new trend appeared, that was to extend the concept of precision feeding to all the dairy farming technologies, and this includes optimizing the production processes by treating individually the cows, with help from automatic sensors. The data presented in this article were collected using the internet and the processing was done in order to create a theoretical basis to facilitate understanding of this concept in the first place, by the dairy specialists, and then by other professionals involved in dairy farming.

Key words*: dairy specialists, new concept, precision dairy farming, precision feeding, theoretical basis.*

INTRODUCTION

Dairy cows are one category of livestock of real interest due to at least two practical aspects: the share occupied by their productions in the total animal production and nutritional and organoleptic quality of their main production, milk. The first is of statistical nature and can be evidenced by the data presented below.

The main productions of dairy cows are milk, meat, hides and manure. Of these, milk represents 85.12% of the total milk production (Figure 1), and the meat, 20.60% of the total meat production (Figure 2).

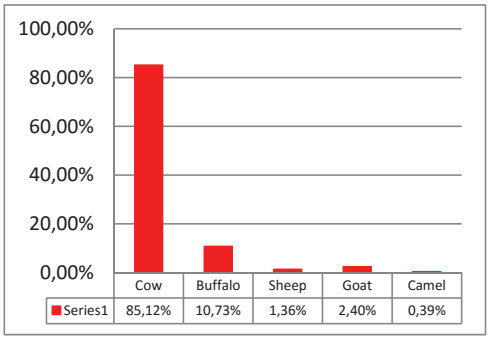

Figure 1. Share of cow milk production in total milk production worldwide
(FAOSTAT 2015 for year 2013)

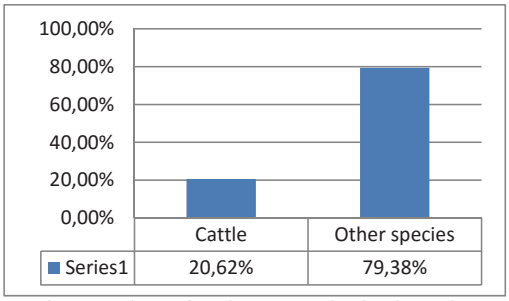

Figure 2. Share of cattle meat production in total meat production worldwide
(FAOSTAT 2015 for year 2013)

In 2013 there were, worldwide, about 1.47 billion heads of cattle and by analyzing the evolution of the livestock of the last 10 years, we can observed a tendency of increasing their number by about 0.90% per year, which totals an increase of 9.00% for this period.

This trend is observed in the case of milk production too, but the growth is more important, of approx. 2.00% per year and 20.00% for the decade to which we refer. In absolute figures, in 2013, it was registered a global production of 636 million tonnes of milk. The more accelerated pace of increase in milk production compared with the livestock number, is due to genetic progress achieved for this species by applying genetic improvement

programs, and due to increase of dairy technologies efficiency.

In Romania, the total cow milk production and livestock decreased during the analyzed period (2004 - 2013) with 12.00% for milk production (from 5.053.100 tons to 4.384.354 tones) and with 37.00% for livestock (from 2.897.000 heads to 2.009.135 heads) while milk production per cow increased by about 21.00% (FAOSTAT 2015 for year 2013).

The major desideratum for the cow milk production is the optimal growth of quality milk production per cow. Total milk production can be determined by the following formula:

Total milk production / unit of time = number of cows * production / cow / unit of time

From the above relation one can deduce that the increase in milk production can be obtained by increasing the livestock and/or increasing milk production / cow. It is generally accepted that increasing the production of milk in an optimum and sustainable manner can be made primarily by increasing production / cow and not by increasing the livestock. This can be achieved through genetic improvement of dairy livestock and by a continue process of modernizing of dairy technologies. In the last 10 years, a new concept appeared in dairy farming, called "Precision dairy farming". Broadly speaking, this modern concept refers to treating the cows individually at all levels and in an abstract mode can be defined as a perfect overlap between what must be done in dairy farming and what is practical done.

MATERIALS AND METHODS

This article is a study, based primarily on information available on websites specialized in Precision Dairy Farming (PDF) field, and also on the results obtained so far and published in various scientific papers. The practical necessity of such article is proven by the results of the survey done among specialists in the field. The results of this survey revealed that respondents do not have a clear definition of the concept of PDF, primarily because of the novelty of the concept and secondly due to the fact that in Romania this topic has not yet been studied thoroughly.

The first step consisted in identifying sites of real interest for the this paper, and then, using the available information, we tried to create a theoretical base on PDF meant to provide answers to questions such as: what is PDF?; which are the means of implementing the PDF in dairy farms?; which are the objectives of implementing the PDF?; what are the advantages of PDF and how they can be quantified at the dairy farm level?; which are the developing directions of PDF?; etc.

RESULTS AND DISCUSSIONS

The survey. The survey was conducted in January 2016, among Romanian specialists in dairy farming, in order to determine the level of knowledge and the opinion of respondents on PDF. The data were collected using a questionnaire which contained eight questions of which, the first two were designed to identify the respondents and the other six remaining questions role was to determine the respondent's link with the dairy farming sector and her/his knowledge about PDF.

27 people responded to the questionnaire. Figure 3 shows the age structure of the respondents, and table 1, their link to dairy farming sector.

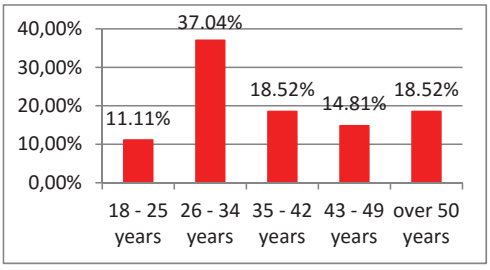

Figure 3. Age structure of the respondents

Table 1. Link to dairy farming sector

Link	% of respondents
New graduate[1]	7.41
Student (Master, PhD)[1]	40.74
Manager in dairy farm	7.41
Dairy farming specialist	44.44

It should be noted that this survey should be continued in the need to increase the representativeness of dairy farm managers.

[1] Specialized college (animal husbandry, veterinary medicine, agriculture, etc.)

Also, by "experts in the field", we will understand researchers, academics and advisors in various fields such as nutrition, reproduction, genetic improvement, etc.
74.07% of respondents say that they know at least one dairy farm that uses sensors.
Data are centralized in Figure 4.

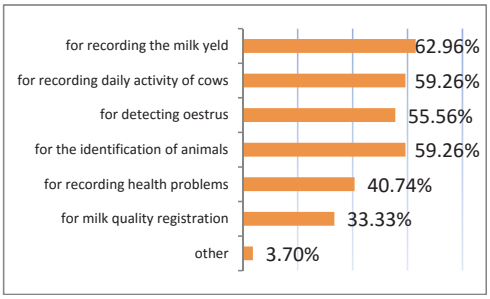

Figure 4. Types of sensors and their popularity among respondents

The respondents were asked to give a mark from 1 to 5, where 1 = not at all useful and 5 = very useful, depending on the utility they consider that different types of sensors have. The results are shown in Table 2.

Table 2. The usefulness of sensors based on respondents opinion

Type of sensor	Mark	SE[2]
for recording the milk yield	4.70	0.14
for detecting oestrus	4.67	0.14
for milk quality registration	4.67	0.13
for the identification of the animals	4.63	0.17
for recording daily activity of cows	4.52	0.15
for reporting health problems	4.48	0.19

To determine whether the respondents consider that the use of sensors in dairy farms is an important component of the PDF, we've asked them if they heard about this concept. 33.33% of those surveyed said they had not heard about the PDF concept although, 74.07% of them said they know at least one dairy farm that uses sensors. This can be explained by the fact that some respondents (at least 7.00%) did not consider the simple use of sensors as being PDF, or simply do not know the significance of the concept.
The last question in the questionnaire was designed to reveal how respondents define the notion of PDF. Those who responded to the previous question that they heard about PDF were asked to choose between four definitions of the concept on the one they considered to be most accurate. The definitions used were as follows:

Definition a: *a method that reduce workload and streamline the management process by improving the productivity and the economic outturn, all this obtained by treating individual the dairy cows with help from sensors that collect information automatically from each cow and then process the data with the computer, in order to increase the degree of automation in dairy farms*;

Definition b: *the use of at least one sensor in dairy farms to retrieve various information directly from the cow's body and storing them in a computer*;

Definition c: *the use of information and communication technologies to improve the control that the farmer has on each individual in the herd of dairy cows in order to optimize economic, social and environmental protecttion performance of the farm (Estwood et al., 2012, cited by Borchers and Bewley, 2015)*;

Definition d: *a new technology that determines the increasing of automation in dairy farms*.

The results for this question are shown in Figure 5.

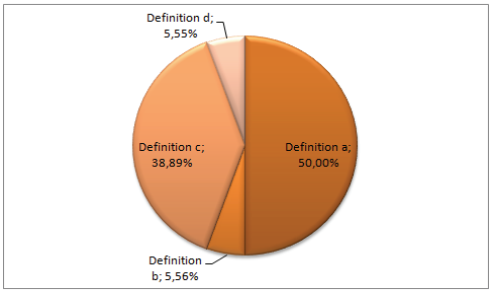

Figure 5. The way respondents define the notion of PDF

Given the results of this survey, one can conclude that persons involved in the dairy farming do not have a unified vision of the concept of PDF because, in Romania, this issue

[2] Standard Error

has not been yet addressed by researchers in the field of dairy. Also, worldwide, although there are concrete results on this subject, they are still not integrated as a whole, a situation that hampers understanding of the concept by specialists.

Definition. To understand the concept of PDF, one must start from the premise that the dairy farm is a productive unit that exists in the context of market economy and can be defined, from this point of view, as an economic system that has the particularity that the optimization process is strongly influenced by biological restrictions (Kelemen et al., 2015). For this reason, the main objective of the dairy farm is to maximize the profit because profit gives the possibility of dairy farm development and, at the same time the sector development and, finally, the livestock industry development.
In this context, PDF is an integrated subsystem whose role is enhancing the efficiency of management by individualizing dairy cows with help from sensors that collect information from each cow and computer processing the data in order to increase automation of the dairy technologies, so, the farmer's control over every individual in the herd significantly increases and makes it possible to optimize the economic, social and environmental protection performance of the farm (Estwood et al., 2012, cited by Borchers and Bewley, 2015).
PDF's main objectives are to (http://www.precisiondairyfarming.com/): 1) maximize animal performance, 2) detect diseases in individual cows early, 3) detect herd level health and production problems early and 4) minimize the use of medication through preventive health measures. In addition we can mention: optimizing the size of the dairy farm, reduce the expenses, streamline the feeding technology, improvement of animal welfare, etc.
At EU level there is ongoing the EU - PLF project which aims to bring the results of research in practice. The main objectives of the EU - PLF are (http://www.eu-plf.eu): 1) determine key animal welfare, productivity and health indicators (KIs) and gold standards that can be related to automated and continuous data stream, 2) perform extensive field tests of a few tools currently available at laboratory level or as prototypes, 3) analyse the data obtained and derive integrated solutions to make PLF a service to the farmer, 4) define the value created by the use of the PLF tools, 5) facilitate PLF-related innovation through High-Tech SMEs, 6) create the innovation blueprint and 7) disseminate the project results.

The sensors. The extrapolation of the precision concept from the feeding technology to the entire dairy farming technology was made about 10 years ago (Muller and Schrader, 2003; Munksgaard et al., 2006), by the introduction of specialized sensors used to measure various parameters like cows activity or their physiological state. To this end, a number of scientific papers have been published to validate the performance of these sensors or for developing various models through the data collected can be exploited in an optimum manner. One of the first articles that discussed this topic was conducted by Trenel et al. in 2009. The objectives were: recording the motion behaviour of the animal (walking, body position) and developing a filtering procedure that detect the position with greater accuracy. IceTag sensor (icerobotics.com) was created to measure the intensity of the upright or lying posture of the calves and daily activity as a percentage of time that the animal spends lying down or in an ortostatic position. The authors have developed a 3-step procedure that was intended to improve the precision and accuracy of data provided by the sensor. The experiment has shown that the procedure improves the quantifying of the number and the duration of positions taken by the calves, but the locomotion measurements should be used with extreme care.
Andre et al. in 2011 published the results of an experiment that they conducted with the objective of quantifying the effect of stress caused by high temperatures on average daily milk production. To collect the data for the experiment, they used database from 2003-2006 period, made through automation techniques of the process in the dairy farms. The authors conclude that estimating these effects is helpful in identifying those factors of management (grazing, technology maintenance, feeding technology) that have an impact on how the animals are feeling the heat stress, and

by manipulating these factors the dairy farmer can reduce stress.

Liang et al. conducted in 2013 a study on the influence of race, milk production, season and the ambient temperature on the body temperature of dairy cows measured at reticulo-rumen level. The authors concluded that the results may be useful for interpreting data obtained with the use of automatic recording systems of the temperature and also for heat stress management and genetic selection for cows with high tolerance to extreme temperatures.

In 2013 Rutten et al. made a bibliographic study regarding automated systems based on sensors used for health management in dairy farms. The purpose of the researchers was the systematization of these technologies into four levels depending on the complexity of the outcome: (I) techniques for measuring the parameters of the cow's body; (II) the interpretation of registered values to get information about the cows; (III) integration of information obtained with other information to create management strategies; (IV) systems that facilitate the management process and/or it automates it. Based on 126 scientific papers published in the period of 2002-2012, that analysed 139 sensors, the authors determined that 25.00% of them have been made in order to identify mastitis, 33.00% for fertility problems, 30.00% for measurement of the cows activity, and only 16.00% for detecting metabolic disorders. The sensors used in practice up to that point were of level I and II, and those of levels III and IV, did not exist. Another important observation revealed that the sensors are influenced by the performance of the algorithm used for data processing and by the size of the sample. The most advanced automated systems based on sensors are designed for diagnosing the mastitis and the oestrus. The authors did not identify works that discuss the issue of integrated decision models based on data collected.

A recent paper with a very pronounced practicality was published in 2015 by Borchers and Bewley. The study was conducted in March 2013 using an online questionnaire, and in May 2013, data collected from 109 respondents have been statistically processed. Dairy farmers were asked to choose from a predetermined list what kind of sensors they have in to the farm. Among the surveyed farmers, 68.8% use such technologies as follows: average milk yield (52.3%), cows daily activity (41.3%) and mastitis (25.7%). Farmers also indicated the usefulness of these systems on a scale from 1 (not at all useful) to 5 (very useful): mastitis (4.77 +/- 0.47), estrus (4.75 +/- 0.55) and the average milk yield (4.72 +/- 0.62). This result is similar with the result from the survey presented earlier in this paper. Another objective of the study was to determine the importance that farmers assign to certain aspects before deciding to buy a technology for implementing PDF concept in their farms. The results revealed that the most important indicators are cost / benefit ratio (4.57 +/- 0.66), the cost of investment (4.28 +/- 0.83) and ease of use (+/- 4.26 0.75).

PDF, animal welfare and costs. The study and implementation of the PDF have started from the premise that between this concept and the various aspects of dairy farming there is a significant correlation, which, once determined and understood, can be the basis for an integrated optimization of the economy of milk production, having in regard the context which involves acerbic competitive environment, cyclical imbalances of the milk market, availability of resources, bio-nutritional value of cow milk, etc. The two aspects mentioned in the title[3] are crucial for the economic efficiency of the farm and the dairy sector. How they interact is complex, derived from dairy technologies and genetic quality of animals and integrated at a macroeconomic level and food security of mankind, so we can say that the precision with which they are managed is a current topic of real importance!

Animal welfare can be defined as a complex concept involving scientific, ethical, economic and political dimensions of a real importance (Lund et al., 2006), and it represents the quality of animals life. In addition to this definition, welfare supports many other definitions more or less complete, accurate and sometimes contradictory. For this reason, measuring this parameter in the dairy farm can be difficult.

However, from the objective perspective of PDF, welfare of dairy cows can be seen as

[3] Animal welfare and costs.

being the degree in which the cow's necessities are satisfied in relation with availability of resources. So, from the point of view of optimising dairy technologies, welfare is a restriction in dosing the production factors in the sense that imposes the minimum level of the allocated resources , so that, the dairy farm will achieve the maximum economic efficiency with a minimum cost and the animals will benefit from an enhanced quality of life. The maximum limit of animal welfare is, in turn, imposed by the need of the production units to generate maximum profit. Graphical representtation of interrelations between welfare and resource availability and welfare or resource availability and profit may look like in Figure 6.

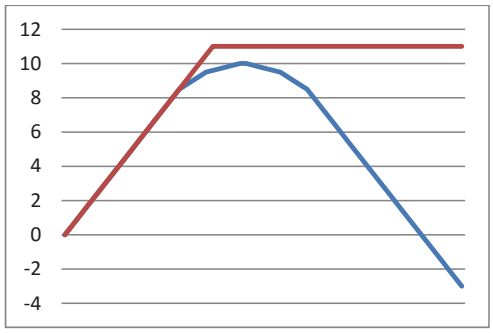

Figure 6. The possible interaction between welfare and resource availability (red) and the possible interaction between profit and resource availability / welfare (blue)

Chart 5 highlights that increasing the availability of resources, namely the degree of welfare, can have a huge positive correlation with the profit as long as the increased availability of resources generates increased profits. Functions appear to be rather nonlinear.
So far, the relationship between welfare and economic efficiency was not clearly determined, but past studies indicate that the application of this concept has a major impact on the productivity of animals.
Another important aspect of the link between welfare and PDF is the fact that by using automatic sensors and processing the data collected by them with the computer, we can estimate how animal welfare at farm level evolve over time and in relation to other aspects of the dairy technologies, such as milk production, production quality, health, natality, fertility, economic efficiency, etc Regarding costs, the hypothesis is that by applying the concept of PDF, although there are generated relatively high investment cost, long-term impact is to reduce production costs, and consequently, increase the economic efficiency of dairy farms.
Given the share of feeding costs in total costs, the objective of one of the published studies was to evaluate the economic impact of the use of precision feeding technologies in dairy farms. The economic analysis was done in order to predict revenue, taking into account the cost of feed and labour (White and Capper, 2014), given that precision feeding plays a role in optimizing the economical and ecological performances by achieving a production of quality milk that is accepted by most consumers (Spilka and Fahr, 2003). Precision feeding has a major impact in the management activity of the dairy farm because it increases efficiency, reduces costs, improves milk quality and the health and welfare of the herd (Bewley, 2010). A number of other studies argue the positive impact of PDF on the economic outturn because it helps to balance the nutrients in the farm by improving the productivity due to matching of the administered ration to the nutritional requirements of an individual or group of animals (Wang et al., 2006b; Cerosaletti et al., 2004; Ghebremichael et al., 2007; Gehman, 2011). Experiments performed under practical farm conditions confirms to the benefits of precision feeding, so, by monitoring the feed intake of dairy cows, the DM intake can be optimized (Halachmi et al., 1998), and by implementing decisions based on the information analysis systems developed by PDF, milk production and the revenue can increase (Andre et al., 2007).
In 2014, White and Capper have published a economic analysis of formulating rations with increased frequency. For this they considered the following: 1) the costs were represented by the cost of feed and labour and 2) the income from milk was the only source of income used. The conclusion of the study for the economic analysis, was that the implementation of precision feeding at dairy farm level improves economic efficiency in general, since any increase in costs is attenuated by increased profitability due to increases recorded in the production of milk.

Romania and PDF. Milk is an essential aliment, at least for the harmonious development of children, having a functional role in human nutrition. Therefore, we can expect an increase in demand for milk in the coming years, growth that must keep pace with demographic evolution. In the next 35 years, FAOSTAT expects that in 2050, the human population will be approximately 30.00% higher than the current situation. Livia Vidu, in 2002, argues that an important indicator for assessing the standard of living is milk consumption / capita. According to data published on the website EUROMONITOR, milk consumption in Romania has an upward trend, which demonstrates the need to increase average milk production / cow. Currently, Romania is disadvantaged by the average milk yield / cow (3.447 liters) compared to that in EU (6.085 liters); (Average for the period 2004-2013) (FAOSTAT 2015 to 2013). To this is added the low efficiency in the exploitation of dairy cows in our country, due to the lack of coherent and sustainable politics for this strategic sector. Same with the ratio between imports and exports of raw milk, that is unbalanced in our detriment. In 2012, the value of imports was approximately 11 times greater than that of exports. There are still premises for the installing of an equilibrium regarding import / export relation, due to lower growth rate of imports (average for the period under review, 150.00%) than that of exports (average for the period under review, 188.00%).

Although Romania has never achieved the limit imposed by the allocated milk quota, the elimination of it represents a real threat to the Romanian dairy sector, in the context of weak productive efficiency and the mediatic scandals. The vehiculated scenario supposes that the import of milk in Romania, from countries such as Hungary or Poland, will increase. The specialized press highlights the tendency of dairy farmers, from countries with great performance in this area, to increase the livestock. In addition, milk processors from Romania prefer the imported milk due to the following reasons: 1) the possibility to supply at regular intervals and with optimal amounts, in terms of transport and flux of production; 2) hygienic and sanitary quality of milk easier to control because of the possibility of cooperation with a smaller number of optimally sized dairy farms and 3) easiness in supply. In Romania, in mountain and hill areas (about 66% of the country) there are areas inaccessible to the cars that transport the milk.

In this context, it can be concluded that Romanian dairy farms are vulnerable in the face of near future, and one of the methods handiest for farmers to ensure increased productivity and economic outturn is efficient management.

CONCLUSIONS

In Romania, the PDF concept has not yet been thoroughly studied and therefore, specialists and farmers do not have a clear vision of this modern notion.

PDF is a modern and opportune solution for optimizing the dairy farming technologies, including in Romania, given the global context of the sector that implies the increasing of demand for quality food due to acceleration of demographic growth.

PDF is the concept of integrated optimization of all the dairy technologies, but also enable the optimization of the whole sector of milk production because it takes into account the effects that management decisions may have on the environment in which the dairy farm exists (market economy).

PDF concept is relatively new, appearing for the first time around 2000s in dairy feeding, and then, was extended to the entire dairy farming during 2005-2010 period.

Studies published so far prove the existence of an interrelationship between the PDF and the various aspects of the economic efficiency of dairy farming (animal health, welfare, costs, etc.).

It is necessary to deepen the studies if we want to determine more accurate the impact that precision technologies have on economic efficiency of dairy farms, both worldwide and in Romania.

ACKNOWLEDGEMENTS

We wish to thank everyone who took the time to complete the questionnaire and in this way they made possible our study.

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