Interpretation of analytical results by the expert system

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Summary

Profitability of dairy cow production is influenced by good health condition of animals. Productive disorders (PD) resulting from improper technological systems of housing, inadequate nutrition and feeding regimens or improper milking system represent a serious problem. PD are associated with a significant reduction of milk quality and milk yield. Preventive system (PS) of PD is very important as well. The results of milk sample (MS) analyses must be properly evaluated. It forms the basis of an effective control, regulation or positive modification of the PS. Numerous compositional, qualitative, and health parameters can be now systematically controlled in MS. Results of analyses can be compiled, archived, and evaluated. A software application used for systematic evaluation of MS analyses (bulk MS and individual MS) - OptimLact - was studied as an expert system. Study was based on a conditional and causal model and on a probability model as well. Milk secrection disorders and metabolic disbalances were the principal objectives of the study. Efficacy of statements never reached 100 %; incorrect diagnostics of approximately 5 - 10 % is envisaged. So-called "advisory minutes" (AM) are the final product of OptimLact. AM confronts results with adopted standards and physiologic limits, demonstrates evolutionary trends, and confronts historical data with actual ones. AM summarises eventual recommendations and modifications of the PS. It is suitable for routine dairy laboratories. Method is profitable; its application is associated with reduced standard time of individual animal care.

Key words: productive disorders of dairy cows, results of milk sampling, prevention, software, milk secretion disorders, metabolic disbalances, interpretation

Introduction

Stable profitability of milk production is associated with an optimum level of milk efficiency and top milk quality. These parameters are influenced by good health condition of dairy cows. Increased incidence of productive disorders (mastitis, laminitis, postpartal paresis, stress, metabolic disbalances, acidosis, alkalosis, ketosis) including reproductive disorders is the principal factor threatening profitability of milk production. The mentioned productive disorders result from inadequate and improper technological conditions - housing system, milking system, nutrition and feeding regimens. Higher production levels are

associated with higher risks. Therefore, prevention is considered as the most effective method for reduction of economic loss caused by increased incidence of productive disorders. In general, productive disorders are characterised by:

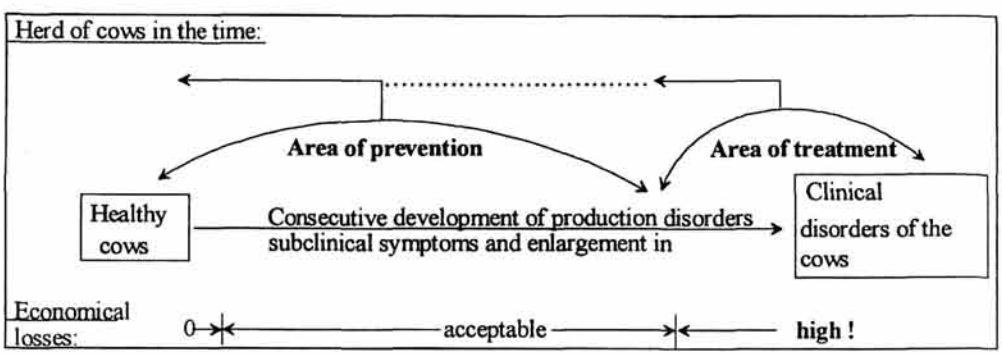
- persisting effects;
- several times (sometimes by one magnitude of order) higher subclinical frequency forms compared to clinical ones;
- significant negative impact of subclinical forms on milk production and milk quality.

With respect to the mentioned facts, prevention is more efficient than curative interventions and, in most cases (Fig. 1), procedures applied later - in the stage of clinical symptoms. It is supposed implicitly that good prevention system requires an effective, regular, financially tolerable area monitoring for a reliable discrimination of more severe subclinical forms of productive disorders. The actual world-wide trend is based on regular monitoring of composition and parameters in bulk milk and individual milk samples. Numerous milk parameters can be used as relatively reliable indicators of dairy cow health - so it is possible to prognosticate risks of increased frequency of productive disorders.

It is logical that monitoring of individual milk samples included in milk recording system is characterised with higher informative efficacy as compared to that of bulk milk samples. In spite of this, the two mentioned informative sets are useful and profitable (Hanuš, 1998.). The mentioned monitoring systems can serve - according to numerous bibliographic references, (see list all references at the end of paper) - as the basis for:

Fig. 1: Scheme of a prevention program aimed for the prevention of milk production decrease resulted from productive disorders - metabolic imbalance and milk secretion disorders above all

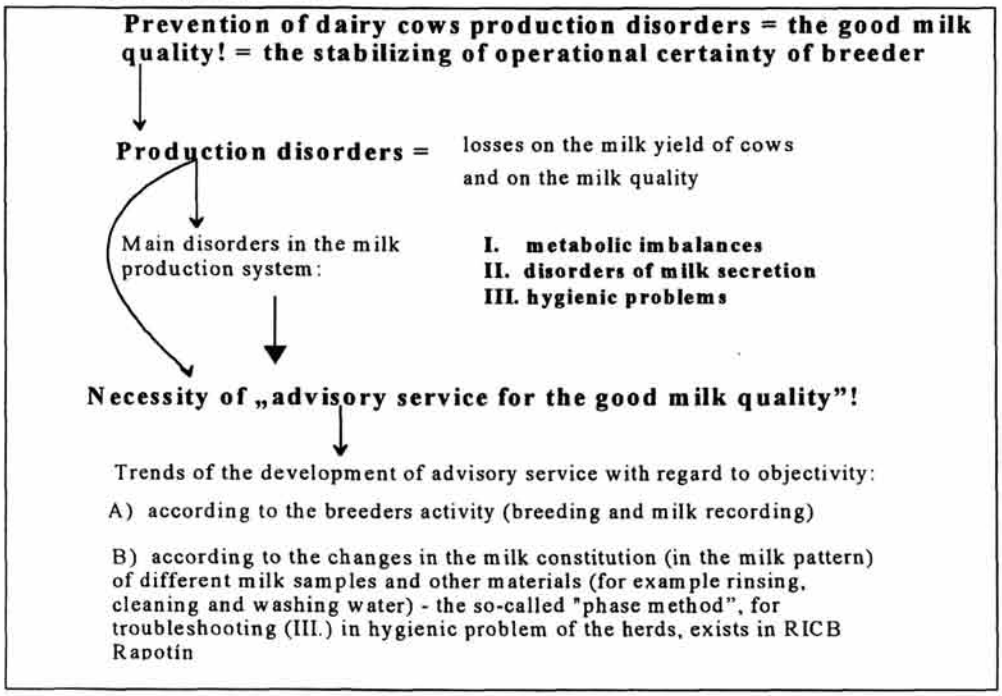
Slika 1: Shema programa za prevenciju smanjene proizvodnje mlijeka nastale kao rezultat poremećaja proizvodnje - poremećaji u metabolizmu i iznad svega u izlučivanju mlijeka



- estimation of nutrition level in dairy herds;
- prognosis of productive disorders frequencies and negative impacts of these disorders on milk quantity and milk quality;
- detection of potential risks, well-timed positive and effective application of standard preventive measures in dairy herds.

Information, characterising the dairy herds, makes a useful basis for consulting service action in milk production sphere - Figs. 2 and 3.

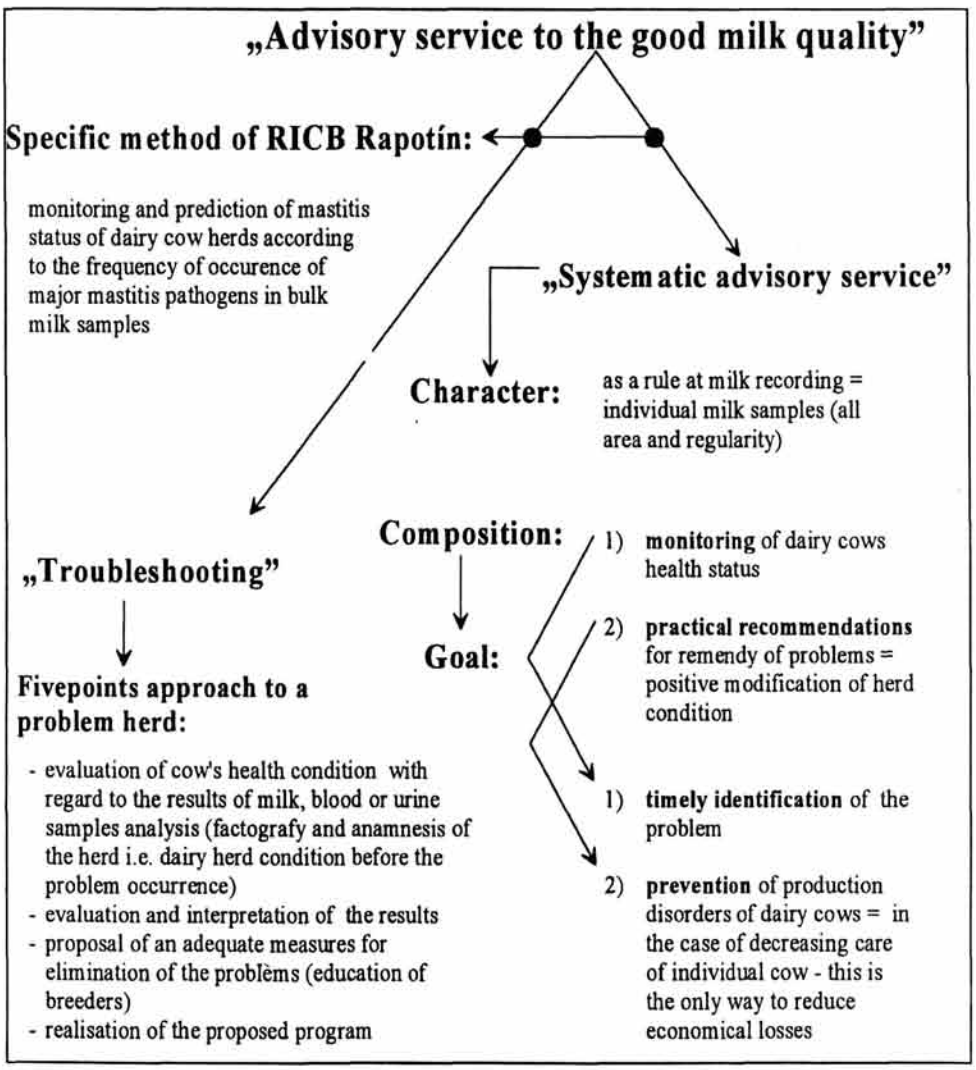
Fig. 2: Practical systems development of health and milk yield control of dairy cows
Slika 2: Razvoj praktičnih sustava u kontroli zdravstvenog stanja i prinosa mlijeka kod mliječnih krava



Supporting factors:

1. The mentioned positive facts can attribute to the favourable trend in technical progress. Nowadays, routine dairy laboratories are equipped with high capacity and adequate accuracy, automatic, simultaneous instrumentation - e.g. IR analysers (Milko-Scan, Foss Electric; Bentley 2000) used for principal milk constituents analysis or Ureakvant (product of Czech Republic) used for milk urea analysis (Jilek Laboratory service Postřelmov, 1997; Ficnar, 1997; Skyva, 1997; Fig. 4). Therefore, relatively comprehensive and regular characteristics - composition and parameters - specifying various types of milk samples are accessible.

Fig. 3: Practical systems development of health and milk yield control of dairy cows
Slika 3: Razvoj praktičnih sustava u kontroli zdravstvenog stanja i prinosa mlijeka kod mliječnih krava



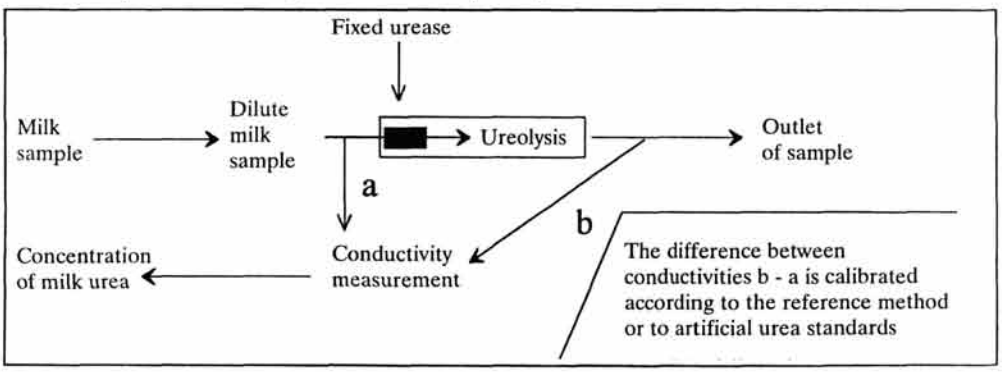
The principal advantages of this conception are:

- existence of routine milk sampling systems;
- easy method of milk sampling - as compared to other body fluids - i.e. systematic, regular sampling excluding stress in sampled animals;
- relatively low costs of routine milk analyses;
- 2. Application of effective computer programs is the other positive factor. The application software, for principal productive disorders monitoring and

preventive program regulation, providing valuable biological services, is used in dairy laboratories, companies and agricultural enterprises of developed countries. The following references specifying algorithms, functions, calculations, graphic methods leading to interpretations applicable in practice can be mentioned:

- in Minnesota, the program "SCC as an effective method of mastitis control" (Reneau et al., 1983, 1988) contributes to the prevention of milk secretion disorders based on compared actual and archival evaluations of individual SCC scores. The similar variants are also used in other countries - Canada, Slovenia (Kopčič, 1998);
- in Australia, interpretation models of individual SCC "Interpretation of somatic cell counts" (Ryan, 1993) has a similar effect as the above mentioned program;
- in Bavaria and Switzerland, an interpretation program is realised by consulting service (prevention of metabolic disbalances) - this program is based on milk constituents (urea, protein, SCC), determined in individual samples, and productive parameters (milk production, lactation order, lactation stage, index of persistency etc.) confrontation (Duda and Korndörfer, 1994; LKV in Bayern, 1991-95; Ledermann, 1994, 1995). Numerous comparable applications are used in other countries (Skyva, Agro-Service Moravia-Silesia, Olomouc, 1997; Veauthier, 1998; Kopunecz, Central Laboratory Pardubice, 1998; Reelitz and Feucker, 1998; Pichler, LKV Niederösterreich, 1998).
- in Bavaria, a model characterised by the sliding horizontal comparison - regions/enterprises - of the chronological pattern of milk composition and milk parameters is used as an informative source in dairy herd management system (Spörl and Roth, 1991; LKV in Bayern, 1991-94). A similar variant is formed in C.R.(Benda, Hanuš, Illek, 1997).

Fig. 4: General scheme of the principles characterizing UREAKVANT method
Slika 4: Opća shema koja karakterizira princip UREAKVANT metode



Mottram (1996) included the similar procedures into the system of non-invasive monitoring of metabolic and health conditions of dairy cows. Development of this application software is constantly improving, according to new research, experiment and experience facts. In general, quantification of the corresponding effects, correction and perfection of discrimination levels and informative capacity are realised continuously with respect to the local specific conditions. The mentioned systems cannot be considered as universal remedies. Obtained results could not be taken as a dogma. In spite of this, it is necessary to mention their satisfactory informative efficiency related to the reduction of medical costs, improvement of dairy cow production etc.

Practical application of the systems, improving prevention of productive disorders, can favourably contribute to realisation of actual general principles characterising foodstuff industry philosophy. This is based on consumer's health protection by means of monitoring health condition of farm animals, quality of raw materials, technological procedures, and above all on quality of foodstuffs (Directive 92-46-EU, Codex Alimentarius, HACCP systems). As for the dairy industry, good-quality milk foodstuffs can be obtained exclusively from milk produced by healthy cows - preference of this hypothesis is evident and logical. The mentioned strategy would contribute to EU directives realisation and improved competitiveness of agricultural products and foodstuffs. General principles of the proposed conception correspond also with theses mentioned in some papers published in EAAP Proceedings (Hamann and Krömker, 1996; Mottram, 1996).

Material and methods

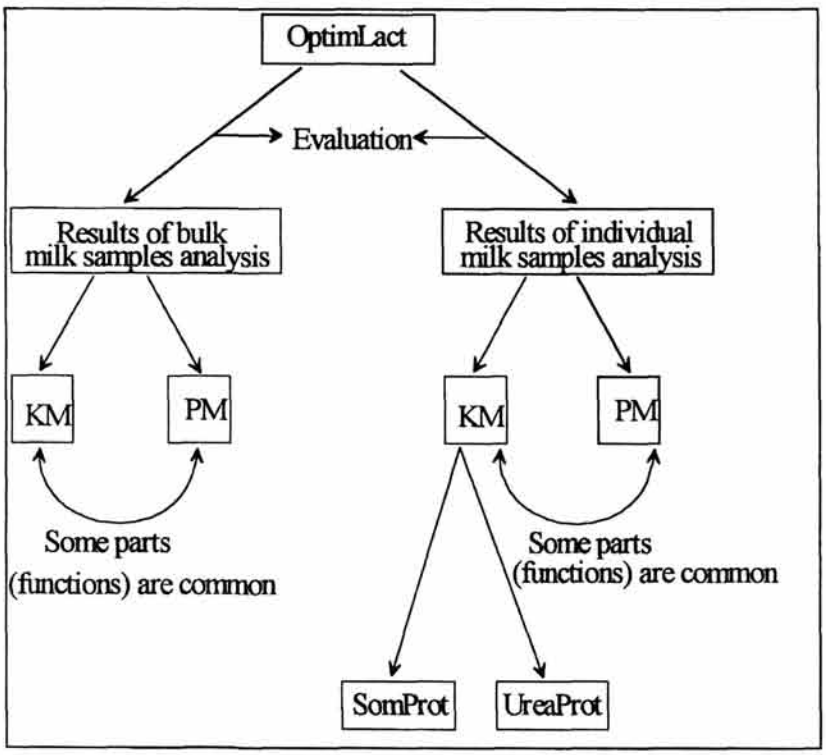
Results and experiences of the research team (RICB Rapotin) as well as recommendations and results mentioned in bibliographic references (see list all of references at the end of paper) were used for specification of algorithms, discrimination levels, and profitability associated with the applied interpretative software.

The algorithm for the software (OptimLact) was proposed in two variants - functioning separately on the basis of bulk milk samples and individual milk samples analysis (Fig. 5):

1. *classic variant, i.e. conditional and causal models (KM)* - positively tested table schemes for health condition estimation based on milk analysis (composition, protein×urea, lactose×SCC, incidence of principal pathogens etc.) were used for model construction. Additional factors (e.g. milk yield, lactation order, lactation stage etc., Fig. 6) were respected as well. In addition, time dynamics i.e. time confrontation of the data was also taken into consideration. The sliding, horizontal, region-enterprise comparison was studied and expressed in the graphic form. This variant is relatively fixed, only discriminative levels of milk

parameters can be corrected. However, an eventual inclusion of new milk parameters is limited. Fig. 7 illustrates division of the model into two parts: analysis of milk secretion disorders (SomProt) and nutritional parameter analysis (UreaProt). The following references were used for this construction: Famigli Bergamini, 1987; Duda and Korndörfer, 1994; Hanuš et al., 1994; Kirchgessner et al., 1986; Ledermann, 1995, 1998; LKV Bayern, 1991-96;

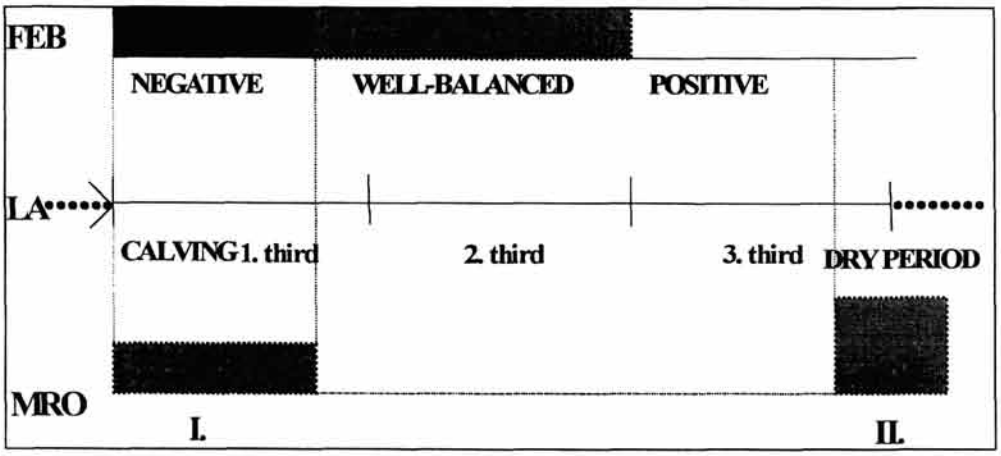
Fig. 5: Structure of the main parts of OptimLact software
Slika 5: Struktura glavnih komponenti OptimLact programa



Ryan, 1993; Spörl and Roth, 1991; Ticháček et al., 1997; Benda et al., 1997. The system utilise few parameters - the set of required parameters should be complete;

2. *non-traditional variant i.e. probability model (PM)* - probability matrix for interval distribution of milk parameters (formed with respect to the data mentioned in bibliographic references) was used for construction of the model. Actual situation (actual values of milk parameters) is confronted with its distribution in the matrix - the most probable situation is chosen as the interpretative one. These results can be complemented with a graphic pattern of the sliding, horizontal, region-enterprise comparison for studying dynamics of milk param-

Fig. 6: Coincidence of mastitis risk periods (MRO) and phases of energy balance (FEB) throughout lactation period (LA) of dairy cows
Slika 6: Preklopivost razdoblja rizika od mastitisa (MRO) i faze energetskog balansa (FEB) tijekom perioda laktacije (LA) kod mliječnih krava



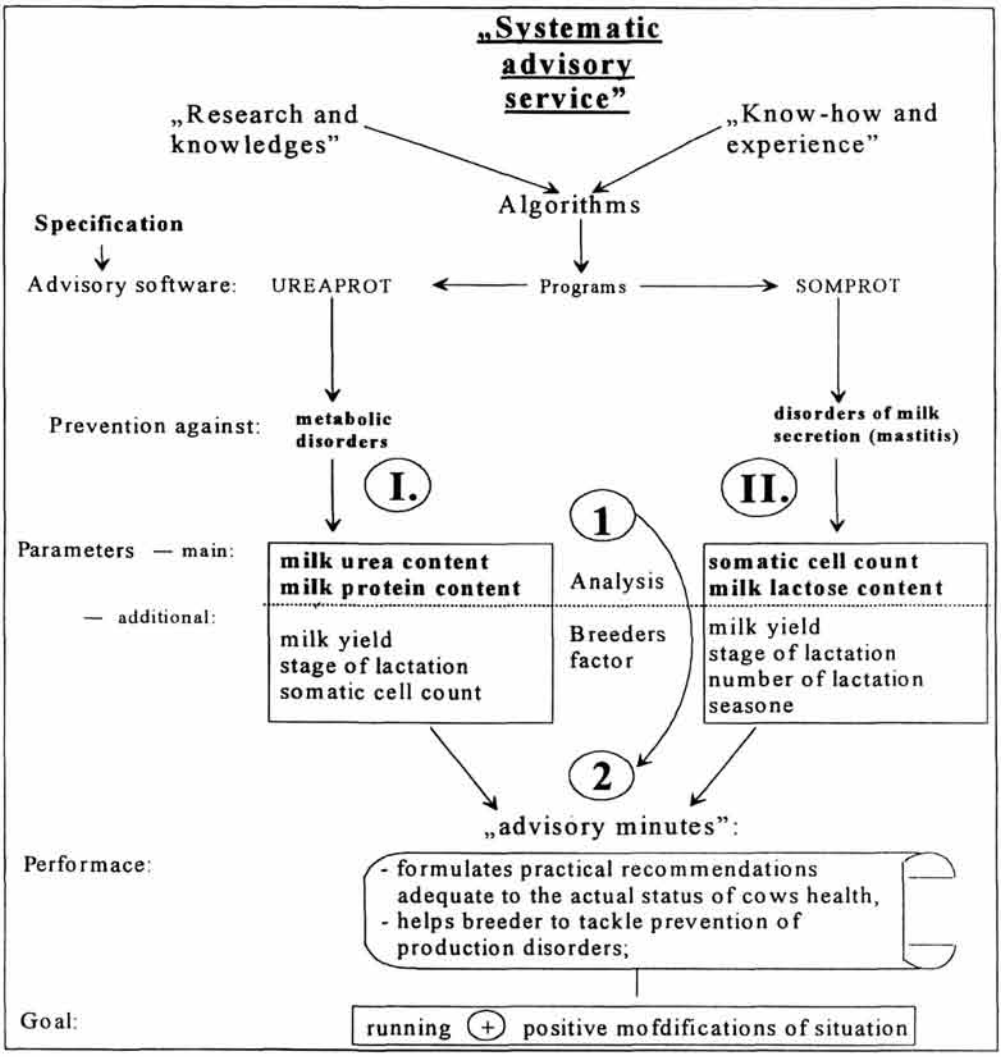
eters and some other interpretative functions transferred from KM model. In this variant, some discriminative levels of milk parameters can be corrected; probability of the correct estimation can be improved. This can be realised by the prospective inclusion of probability characterising interval distribution of newly defined milk parameters into the matrix (in accordance with hypothesized situations in dairy herds). Technical conditions guaranteeing the routine utilisation of these new parameters (e.g. new series of analysers of milk acetone and milk ketones and so on) are necessary for realisation of this intention. The system is easy to modify i.e. it is flexible (it is able to absorb better "instructive" procedure or new experience). Incomplete set of milk parameters is characteristic for the function of the system - probability of the correct interpretation is proportionally reduced.

Results and discussion (list of facts)

1. Key facts - brief specification and justification of the reasons and relevancy of the study:

- productive disorders are caused by technological imperfections, associated with reduced milk quantity and quality, so they present the most relevant economical risk for dairy cow breeders;
- increased milk production is associated with higher incidence of productive disorders in dairy herds;
- predominant incidence of subclinical forms as compared to the clinical ones is characteristic for productive disorders significantly influencing economical parameters of production (milk secretion disorders and metabolic disbalances);

Fig. 7: Practical systems development of health and milk yield control of dairy cows
Slika 7: Razvoj praktičnih sustava u kontroli zdravstvenog stanja i prinosa mlijeka kod mliječnih krava



- tendency of the gradual onset (so called stealthy, i.e. hardly identifiable) and persisting effects (higher economical risks) are typical symptoms of the mentioned productive disorders;
- the mentioned productive disorders initiate typical negative modifications in milk composition, milk qualitative and quantitative parameters;
- the mentioned variation can be used successfully in monitoring of productive disorders frequency;

- monitoring of productive disorders (subclinical forms above all), distribution and frequency makes an important part of the preventive program efficiency;
- prevention system (including preventive treatment of eventual subclinical forms) is the most effective method for control and reduction of productive disorders incidence;
- eventual treatment of clinical forms is expensive and relatively less efficient in most cases;
- nowadays it is possible to control routinely a large spectrum of milk parameters using non-invasive procedures (guaranteeing animal welfare);
- Feedback principle enables regulation of preventive measures suppressing productive disorders incidence in dairy herds and reduce economical loss.

2. Objectives of the study - hypothesised importance and applicability of the interpretative software (OptimLact):

- more effective compilation, processing, and interpretation of the data supplied regularly by routine dairy laboratories;
- regular and well-arranged monitoring of health condition (incidence of subclinical forms of milk secretion disorders and metabolic disbalances above all) in individual cows and in dairy herds;
- processing and evaluation of milk analysis data, specification of dairy cow health condition, proposal of method reducing (eliminating) eventual problems;
- appropriate practical interpretation of numerous data characterising milk composition and milk quality;
- support and regulation of positive modifications associated with prevention of productive disorders;
- increased profitability of milk production (more intensive monitoring of productive disorders incidence, reduction of frequency disorders);
- higher milk quality - raw material for food industry;
- higher proportion of top-quality foodstuffs produced from the first-quality milk (protection of consumer health).

3. Structure of the software interpretation and its application:

The program is used for data processing - results of routine milk analyses. It is divided into two parts (according to the sample type). Each part consists of the data verification filter and the evaluation modulus. Evaluation procedure respects available secondary effects. The analysed results, in case of individual samples, are interpreted in relation to milk secretion disorders, stress, and metabolic disbalances. As for the bulk milk samples, hygienic problems of milk production complete the mentioned interpretation set. Tables and/or graphic schemes are used for the interpretation.

4. Function of the program:

Data characterising milk composition and milk quality are stored into the specific section of the program. They pass through the verification filter module operating on the basis of empirically verified discriminative levels. Verified data are transformed if needed. Processed data are presented in tables or in graphic schemes. Each presentation of processed data is formed as the statement characterising the actual situation or the concrete problem. Tables and graphs are completed with comments or explanatory notes for users.

Estimations of individual health condition or condition of dairy herds or economical loss, related to productive disorders incidence, present the principal objectives of these issues (final data).

The program should prognosticate risk situations and then monitor subclinical health disorders. The mentioned function is linked with the starting impulse for preventive or corrective measures. Specification of the reasons and general proposal of solution is the final objectives of the program. However, these facts do not guarantee 100 % success rate.

5. Application of the results:

Breeders, zootechnicians, and managers should utilise this program. The program can provide numerous data utilisable for positive modifications of the prevention system in dairy herds. Users training process is a very important - more experienced user improve the efficacy of the statements. Estimations are characterised with a specific probability, not with certainty - therefore, some conclusions can be less correct.

6. Disadvantages of the program:

The mentioned uncertainty presents the principal disadvantage of the program. Numerical and graphical interpretations are relatively reliable - some statements (mainly those approaching to specification of the causes and proposed solution of the problems) can be, however, only generals (due to numerous unregistered factors).

7. Advantages of the program:

The regular operation covering the specific territory is the principal advantage of the program. Non-invasive, clear view, instructive (in most cases the processed data are at user's disposition), reasonable financial costs of monitoring, based on milk analysis, are the other positive characteristics of the system as well as possible improvement of the preventive system.

8. Conclusions:

Starting area should be followed by corrections of some discriminative levels, intervals, distribution patterns, probability estimation according to specific condition characterising the actual situation - eventual extension of the functional spectrum can be envisaged, as well.

General practical conclusions

We have to say that there are some general but minor problems (as it was shown), with the introduction and performance of such methods - OptimLact and other solutions -, which occur in the practice. The main abjection of some farmers and experts, in the agricultural advisory services, is that that they expect 100 % system reliability (i.e. 0 % of error) in view of dairy cows health condition estimation and practical interpretation of the problems. However, such system does not exist as each diagnostic work with the biological material includes certain percentage of errors or mistakes occurrence in the practice. It follows that the problems are linked to mistake occurrence or to the probability of the right estimation and interpretation, which never reached 100 %. In consideration of these facts it is necessary to agree with the following definition. "The expert system is usually able to work up, so called uncertain knowledge, i.e. the knowledge which do not categorically express dependence between a phenomenon, but a certain degree of confidence of the validity of investigated reality" (Poledníček, 1999).

We have estimated that the probability of the right interpretation of this expert system can be on the level of about 90 - 95 %. However, if the system (OptimLact) shows some error warnings, in dairy cow's management, the farmer should invite an expert from the advisory service or veterinary surgeon to make an exact diagnosis. In other words there is a need for better interpretation of the results of milk samples analysis and an additional suggestions for better preventive measurements of the dairy herds management. The farmers' warning is made by an advisory minute, which is the product of the programme (OptimLact - according to its algorithms). Advisory minutes serve as either report or a regular help to the farmers for solving easier problems. It helps veterinarians and/or advisory service experts to solve some difficult cases. If we manage to explain this fact to our farmers and agricultural advisory service experts in the right way - which will be acceptable by them - than it will be possible to use such systems in agricultural practice.

We know by now that most of our farmers and experts in the agricultural advisory services realise this fact and understand possibilities and advantage of these routine solutions.

The above mentioned considerations are our own practical experiences. So, we hope that these programmes or solutions will be widely used as an important part of management of primary milk production in the future.

INTERPRETACIJA ANALITIČKIH PODATAKA KORIŠTENJEM EKSPERTNOG SUSTAVA

Sažetak

Profitabilnost proizvodnje mlijeka uvjetovana je dobrim zdravstvenim stanjem mliječnih krava. Neodgovarajući tehnološki sustav smještaja krava u štalama,

nepravilni nutritivni i hranidbeni režimi kao i neodovarajući sustavi za mužnju predstavljaju ozbiljne probleme u poremećaju proizvodnje (PD). Poremećaji u proizvodnji u uskoj su vezi sa značajnim smanjenjem kvalitete i prinosa mlijeka. U poremećaju proizvodnje značajnu ulogu ima i preventivni sustav (PS). Rezultati analiza uzoraka mlijeka (MS) moraju se ispravno procijeniti, što čini osnovu učinkovite kontrole, regulacije ili pozitivnih promjena u preventivnom sustavu. Danas je moguće sistematski kontrolirati niz kvalitativnih i zdravstvenih parametara u uzorcima mlijeka. Prikupljeni i arhivirarani rezultati mogu se dalje interpretirati (procjenjivati). U ovom radu je ispitivana ekspertiza (stručnost) računalnog programa -OptimLact- za sistematsko procjenjivanje rezultata analize uzoraka mlijeka (pojedinačni uzorci mlijeka kao i uzorci mlijeka iz tankova). Ispitivanja su zasnovana na principu modela kojim su obuhvaćeni uvjeti i uzroci kao i model vjerojatnosti. Poremećaji u izlučivanju mlijeka i neuravnoteženost metabolizma predstavljaju glavnu svrhu istraživanja. Kako učinkovitost ovakvog izvještaja nikad nije 100 %-tna predviđa se pogreška u dijagnostici od oko 5-10 %. Konačni proizvod OptimLact programa je tzv. "Savjetodavna minuta" (AM) kojom se uspoređuju rezultati u skladu s usvojenim standardima i fiziološkim ograničenjima. AM također prikazuje razvojni trend te usporedbu prikupljenih podataka s trenutnim podacima mjerenja. Nadalje, AM rezimira eventualne preporuke i izmjene u preventivnom sustavu (PS), te je pogodna u rutinskim laboratorijskim analizama. Metodom se postiže i profitabilnost budući da smanjuje standardno vrijeme potrebno za njegu svake životinje.

Ključne riječi: Poremećaji proizvodnje mlijeka, rezultati uzorkovanja mlijeka, prevencija, računalni program, poremećaji u izlučivanju mlijeka, poremećaji u metabolizmu, interpretacija

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