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## INFLUENCE OF METABOLIC PROFILE IN EARLY LACTATION AND WELFARE SCORE OF FARM TO MILK PRODUCTION AND SERVICE PERIOD IN DAIRY COWS\*

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**Summary:** Assessment of welfare and stress of cows at farms is a priority task for all involved in the milk production. The aim of this study was to investigate the effect of the level of welfare on the farm and metabolic adaptations in cows in early lactation on milk production and length of service period, the risk for the occurrence of below-average productivity of cows and benefits while eliminating stressful on the farm. Milk production and service period as most important productive characteristics of cows are dependent on welfare score of farm (principle of good health and good feeding) and metabolic adaptation of cows. Low welfare score and poor metabolic adaptation in early lactation showed additive effect in reducing of productive characteristics. Risk for decrease of productivity in cows exposed to low welfare score on farm and metabolic stress is higher then 1.9 to 2.8 time compared to cows that did not suffer from same stressors. Reduction of stressors by preventive inspection of locomotion system and hoof corection, determination of metabolic status using a metabolic profile and supplementation with energetics and antioxidants give the best balance of cost and benefit when used together.

**Key words:** cows, welfare score, metabolic profile, milk production, service period.

### INTRODUCTION

Assessment of stress and welfare of cows at farms is a priority task for all involved in the production of milk. Environmental factors and metabolic adaptability of animals affect all aspects of health and productivity of cows. Animal welfare is a degree of its adaptation to environmental conditions (Vučinić, 2006). The most important

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indicators of the health and productivity of dairy cows: milk production and length of service period. Using the protocol Welfare Quality® scoring system (2009) includes assessment of the 4 main principles of welfare on farms cows: good health, good housing, good feeding and appropriate behavior of animals. It also gives the overall assessment of well-being on a farm. Results from previous studies have shown that there is significant between cow productivity and value assessment criteria for good health on the farm, then the criterion of good nutrition and eventually criterion of good accommodation (Cincović et al, 2012). Productive traits such as milk production and length of service period significantly correlated with factors of health, food and accommodation. It is shown that there are differences in the metabolic adaptation of cows originating from farms in which the principles of welfare are met to varying degrees. In cows with lower marks for the principle of health and nutrition there is a higher concentration of stress hormone cortisol, NEFA and BHB. These changes are expressed as the cows in early lactation (when they are most vulnerable to stress), and in the cows in middle of lactation (Belić et al., 2013).

The aim of this study was to investigate the effect of the level of welfare on the farm and metabolic adaptations in cows in early lactation on milk production and length of service period, the risk for the occurrence of below-average productivity of cows and benefits while eliminating stressful on the farm.

## MATERIAL AND METHODS

At nine dairy farm welfare assessment was performed according to the protocol Welfare scoring system (Welfare Quality®, 2009). At the same time, on the same farm was designated a metabolic profile with 15 cows in early lactation (1-15 days after calving). The following metabolic parameters were determined in the metabolic profile: nonesterified fatty acid (NEFA), beta-hydroxybutyrate (BHB), glucose, total bilirubin (TBIL) and Ca (Randox kit and Rayto biochemistry device). At the same cow was monitored daily milk production in early lactation (first 60 days), and length of service period (days). Farms are classified into those with a value of well-being scores were below 50 and with a score greater than 50. The classification of a cow to metabolic profile was performed according to the following critical, risk values: glucose  $<2$  mmol / l, NEFA  $> 0.6$ ; BHB  $> 0.9$  mmol / l; TBIL  $> 9$  mmol / l and Ca  $<2$  mmol / l. The influence of the metabolic status of cows in early lactation and evaluated scores of well-being on milk production (l / day) and length of service period (in days) was determined using ANOVA analysis with posthoc LSD test within the framework of generalized linear models. The model included the effect of the individual, the impact of recent well-being, the impact of metabolite concentrations and the combined impact of the welfare  $\times$  metabolites. Then logistic regression was performed to determine the extent to which environmental factors and metabolic factors affecting milk production and reproductive efficiency by testing of regression parameter. The relative risk was calculated, and it shows how many times more frequently reduced milk production below average farm with cows burdened stress compared to cows with absent of the working stressors or stress reduction is performed. To examine the feasibility of reducing stress factors on the farm was determined percentage ratio between the resources to invest in removing the most common stress-inducing (hoof trimming, metabolic profile assessment, energetic and mineral supplement application, climatisation, balancing of exist meal, induction of reproductive function) and benefits that are realized on this occasion. It was used Statgraphic and SPSS statistical software.

## RESULTS AND DISCUSSION

Results showed that the principle of good health and the principle of good feeding are important factors that affect the productivity of cows. Classification of cows according to the principles of good housing and appropriate behavior did not lead to significant differences in milk production and length of service period, so these results are not shown. Service period was significantly longer in cows originating from farms with lower marks of principles of good nutrition and health. In cows with higher concentrations of NEFA, BHB and TBIL there is also a longer service period. Poor metabolic findings are shown as a intensifying factor. Cows from the farm with a low score of welfare that had a high concentration of NEFA, BHB and TBIL in early lactation show further longer service period. Milk production was significantly lower in cows originating from farms with a low score of the principles of nutrition and health. In cows with a lower concentration of glucose and Ca and higher concentrations of BHB there was a lower milk production. The interaction of environmental factors and metabolic adaptations were not statistically significant. The results are shown in Tables 1 and 2.

All tested parameters are placed in a single logistic model. This model gives correct detection of cows with service period over 120 days in 81% of cases and correct detection of cows with below-average production of milk in 56% of cases. Service period depends primarily on the concentration of BHB and NEFA as well as the assessment of

health on farms. Milk production is determined by the concentration of calcium, glucose and BHB and assessment of quality food. The results are shown in Table 3.

The cows that have inadequate metabolic adaptation in early lactation and live in less favorable environmental factors have an increased relative risk that their milk production is below the expected average, and that the service is longer than 120 days. The greatest risk is at hyper cows on farms where there are lower estimates of the principles of good health and nutrition with increased concentrations of NEFA and BHB. Risk for decrease of productivity in cows exposed to low scores welfare on farm and metabolic stress is higher from 1.9 to 2.8 time compare to cows that did not suffer from the same stressors. The results are shown at the Figure 1.

Elimination of stress factors leads to an increase in milk production and a reduction in calving interval. When comparing the cost of introducing measures against stressors with the benefits that they generate, we conclude that regular inspection and correction hoof metabolic profile and the application supplements allow realizing of 83% of benefit from 47% of total cost of introducing these procedures. The results are shown in Table 4.

**Table 1.** Influence of welfare score of good feeding and metabolic adaptation to milk production and service period in cows

		Score for principle of good feeding <50		Score for principle of good feeding ≥50		Welfare score	Metabolism	Welfare score × Metabolism
		Metabol ok	Metabol risk	Metabol ok	Metabol risk			
NEFA	Service (day)	135±5	149±5	121±7	130±6	<0.05	<0.01	<0.05
	Milk ( )	23±2,5	21±3	26±3,5	24±1,5	<0.05	NS	NS
BHB	Service (day)	141±6	155±6	119±7	133±6	<0.05	<0.01	<0.01
	Milk (L)	24±3	22±2,5	28±2	26±3	<0.01	<0.01	NS
Glucose	Service (day)	132±5	142±8	125±5	122±4	<0.05	NS	NS
	Milk (L)	22±2,5	19±2	26±2	24±3	<0.05	<0.05	NS
Total bilirubin	Service(day)	129±7	139±6	107±5	133±5	<0.01	<0.05	<0.05
	Milk (L)	23±3	25±2,5	24±2	26±3	NS	NS	NS
Ca	Service (day)	129±6	133±5	101±5	106± 6	<0.05	NS	NS
	Milk (L)	22±1,5	20±2	24±2	23±1,5	<0.05	<0.05	NS

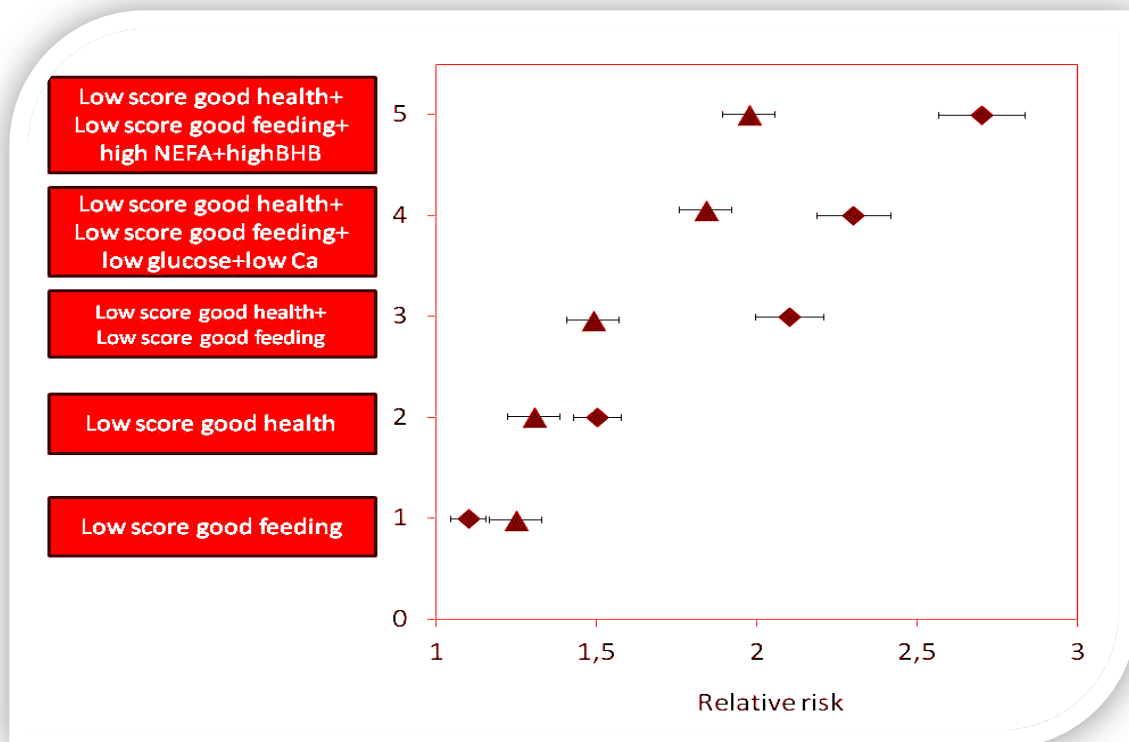
**Table 2.** Influence of welfare score of good health and metabolic adaptation to milk production and service period in cows

		Score for principle of good health <50		Score for principle of good health ≥50		Welfare score	Metabolism	Welfare score × Metabolism
		Metabol ok	Metabol risk	Metabol ok	Metabol risk			
NEFA	Service (day)	133±4	148±6	121±7	130±6	<0.05	<0.01	<0.05
	Milk (L)	24±2	22±3	26±1,5	25±2	<0.05	NS	NS
BHB	Service (day)	139±5	151±6	119±7	133±6	<0.05	<0.01	<0.01
	Milk (L)	25±2	22±3	27±3	25±2,5	<0.01	<0.05	NS
Glucose	Service (day)	133±6	144±8	125±5	122±4	<0.05	NS	NS
	Milk (L)	23±1,5	20±2,5	25±1,5	23±2	<0.05	<0.05	NS
Total bilirubin	Service(day)	130±5	145±4	107±5	133±5	<0.01	<0.01	<0.05
	Milk (L)	22±3	24±3	24±3	25±2,5	NS	NS	NS
Ca	Service (day)	131±7	137±5	101±5	106± 6	<0.05	NS	NS
	Milk (L)	23±2	21±2	24±1,5	22±1,5	<0.05	<0.05	NS

**Table 3.** Influence of welfare score and metabolic adaptation to prediction of cows with above average milk

production and service period greater than 120 days

Parameter	Regression coefficient for milk	p	Regression coefficient for service period	p
NEFA	-0,06	NS	4,5	<0.05
BHB	-0,42	<0.01	3,2	<0.01
Glucose	0,51	<0.05	-0,5	NS
Total bilirubin	-0,08	NS	0,4	NS
Ca	0,44	<0.01	-0,5	NS
Score for principle of good health	0,06	NS	1,1	<0.05
Score for principle of good feeding	0,11	<0.05	0,6	NS
General score of welfare on farm	0,02	NS	0,5	NS
% of correct detection of cows with low productivity	56%		81%	



**Figure 1.** Relative risk for low milk production (triangle) and long service period (rhombus) in cows exposed to low score of welfare and risk metabolic status

**Table 4.** Cost-benefit analysis in implementation of procedures for the reduction of stress

Procedures for reduction of stress	Cost (%)	Benefit (%)
<i>Preventive inspection of locomotion system and hoof corection*</i>	12	30
<i>Determination of metabolic status using a metabolic profile*</i>	28	64
<i>Suplementation with energetics and antioxidants*</i>	47	83
Climatisation	80	89
Additional balancing of meals	86	95
Hormonal induction of reproductive cycle	100	100

\*Procedures marked with an asterisk give the best balance of cost and benefit when used together

Our previous results indicate that the metabolic adaptation cows depends on the level of well-being (Belić et al., 2013): Cows from farm with lower welfare score according to principle of good housing showed a tendency to lower glucose and calcium concentration in mid lactation period. Cortisol concentration was higher in early and mid lactation. Metabolic adaptation of cows in relation to welfare principle of good feeding showed that cows from farm with low scores showed: higher NEFA, BHB, bilirubine and cortisol concentration in early lactation. Metabolic changes in mid lactation showed tendency to higher BHB, and lower glucose and urea concentration. Cows from farm with lower welfare score according to principle of good health showed higher NEFA, BHB and cortisol and lower glucose concentration. The metabolic characteristics of cows depend on providing the principle of welfare on farms. Cows from farm with lower welfare scores showed higher cortisol concentration and signs of metabolic stress, such as higher NEFA, BHB and bilirubin concentration and lower concentration of glucose and urea. The most important principles, which significantly affects these characteristics, are the principles of good health and good feeding. These results show that it is possible to estimate the welfare of cows based on metabolic status, which requires further investigation.

Cincović et al. (2012) showed that on farms with lower level of welfare as well as the poorer implementation of principles of good nutrition, significantly lower milk production was found, as well as a greater percentage of cows with a long service period, lameness and a higher percentage of very thin cows. Providing good accommodation principles will significantly improve milk production, reduce the number of cows with a long service period as well as the ones with lameness, and it is particularly interesting that obliging this principle will provide less subclinical mastitis on a farm and less cows with dystocia and skin lesions. The most important principle, which has demonstrated a significant effect on the values of all parameters, is the principle of good health. Providing the implementation of this principle on farms will result in significant improvement of all parameters of production and health. In addition to medical syndromes such as lameness or dystocia, the score of good health depends on the occurrence of ocular, nasal and vaginal discharge, which supports the infection of the corresponding organs. Productive characteristics such as milk production and length of service period significantly correlate with the factors of health, food and accommodation. Ensuring good health of farm animals is the most important task in the process of securing the welfare and sustainable production on cow farms.

Elimination of stress factors on the farm leads to the improvement of the productive characteristics of cows. Eliminating stress factors included: analyzing the metabolic status and its relation with milk production, health and reproductive efficiency; the application of energetic or antioxidants supplements; regular inspection of hooves and the locomotion system, correction meals and air conditioning facilities. The positive effects of these processes are characterized by improved production and metabolic adaptations.

Milk production is depend of metabolic adaptation in dairy cows (Belić et al, 2014). The results show that cows with lower values of insulin and higher values of cortisol and STH have higher milk production in the first weeks of lactation. However, these relationships are not easy and apparently are caused by other factors, and depend on the week in which we investigated the concentrations of the hormones themselves. When cows classified according to the metabolic status, so to compare milk production between cows with unfavorable and favorable metabolic status at the result showing that cows who have an unfavorable metabolic status (lower concentrations of glucose and calcium and higher BHB and bilirubin concentration) showed lower milk production. Impact of endocrine and metabolic status on milk production has been determined. A relationship between hormones, metabolites, and milk production is complex and must be interpreted within the concept of homeostasis and homeoresis or biological capacity of cows to adjust to lactation but also to maintain the continuity of the body.



Cincović et al (2012a) showed that metabolic adaptation in early lactation is depend of lipide mobilization and ketogenesis. According to NEFA and BHB concentration it is possible to predict metabolic adaptation of protein, lipide and carbohydrate metabolism. Belić et al. (2012) showed that in cows suffering from metritis had a significantly lower number of erythrocytes in the period before calving, and week after calving, while the hemoglobin concentration was significantly lower in the week after calving compared to control healthy cows. Metritic cows had higher leukocyte number in week before and week after calving. Leukocyte profile of these cows was characterized by increased neutrophile percent in week after calving and decreased monocyte percent in week after and week before calving compared to control group. Cows with mastitis showed higher neutrophile percent in week before and week after calving and lower percent of eosinophils in same period compared to healthy cows. NEFA concentration was significantly higher in diseased cows in week after calving. Prediction of metritis is possible in function of monocyte percent and level of anemia. Percent of eosinophil may indicate the mastitis in dairy cows. Cincović et al (2014) demonstrated that reproductive efficiency of cows is in relation with concentration of insulin, IGF-I, NEFA and BHB.

Cows that received propylene glycol are less burdened with metabolic stress (Cincović et al, 2013). Thus, cows treated with propylene glycol have higher concentrations of glucose, insulin, IGF-I and lower concentrations of NEFA, BHB and bilirubine. Post-hock analysis it can be concluded that cows in early lactation show these differences, but the differences in metabolite concentrations before calving were not significant. Cows in which was applied propylene glycol are less burdened by metabolic stress, which is reflected in lower proportion of cows with signs of metabolic stress. Efficacy of propylene glycol may be seen in the fact that propylene glycol is changing relationships and strength of links between metabolites. Davidov et al (2014) showed that selenium and zinc supplementation had significant positive effect on udeer health. In cows supplemented with selenium there was significantly lower number of somatic cells during the following lactation period. In the parenchyma of the udder there was found less pronounced infiltration of leukocytes, notably thicker keratin layer of *ductus papillaris* and less expressed repairing processes that indicate a chronic inflammation of the udder in the samples after exclusion of the cows from production. Zinc from blood and udder had a negative correlation with the number of somatic cells, had a positive correlation with the thickness of *ductus papillaris* keratin layer and had no influence on the level of leukocyte infiltration of udder parenchyma.

Toholj et al. (2012) showed that etiopathogenesis of musculoskeletal disease tract or acropodium, is complex and includes some classic, like many emerging factors in intensive production. It was found that in a free way of keeping the percentage of patients suffering from digital dermatitis significantly higher. The emergence of the hoof Rusterholzu ulcer was significantly higher in cows tied in the way of keeping in relation to the cows in the free housing. Digital dermatitis, also known as digital or interdigital papillomatosis is an infectious disease of cattle, which is considered one of the main causes of lameness. Its causation is multifactorial and complex pathology and it is described in this paper. Ultrasound examination of hoof could provide early detection of sole ulcer in dairy cows (Toholj et al., 2014).

Cincović et al (2013a) demonstrated that air conditioning during heat stress improves milk production with important metabolic adaptation. Exposure of cow to fan leads to an increase in milk production and an increase in food consumption, but it does not reach the values that existed in the optimum temperature action. Metabolic characteristics of cows after exposure to fans were as follows: lower pH levels, higher blood glucose and insulin value, the tendency of increase of the concentration of NEFA and reduced sensitivity to insulin, while the concentration of T3 and T4, cortisol and growth hormone showed a tendency to increase. The parameters that indicate the degree of hydration of cows (hematocrit, total protein and creatinine) were not significantly different.

## CONCLUSION

Milk production and service period as most important productive characteristics of cows are dependent on welfare score of farm (principle of good health and good feeding) and metabolic adaptation of cows. Low welfare score and poor metabolic adaptation in early lactation showed additive effect in reducing of productive characteristics. Risk for decrease of productivity in cows exposed to low welfare score on farm and metabolic stress is higher then 1.9 to 2.8 time comparet to cows that did not suffer from same stressors. Reduction of stressors by preventive inspection of locomotion system and hoof corection, determination of metabolic status using a metabolic profile and supplementation with energetics and antioxidans give the best balance of cost and benefit when used together.

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## UTICAJ METABOLIČKOG PROFILA U RANOJ LAKTACIJI I OCENE DOBROBITI NA FARMI NA PROIZVODNJU MLEKA I DUŽINU SERVIS PERIODA KOD MLEČNIH KRAVA

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**Izvod:** Ocena dobrobiti i stresa na farmama krava predstavlja veoma značajan postupak za sve ljude uključene u proizvodnju mleka. Cilj ovog rada je da se ispita uticaj nivoa dobrobiti na farmi i metaboličkog statusa krava u ranoj laktaciji na proizvodnju mleka i dužinu servis perioda kod krava, da se oceni rizik za nastanak ispodprosečne proizvodnje krava i uradi analiza ulaganja i profita koji postoje prilikom uvođenja mera za otklanjanje stresnih faktora na farmama. Proizvodnja mleka i dužina servis perioda kao najvažnije produktivne osobine krava zavise od ocene dobrobiti na farmi (principi dobrog zdravlja i dobre ishrane) i metaboličke adaptacije krava. Niska ocena dobrobiti i loša metabolička adaptacija pokazuju aditivni efekat dovodeći do pada u produktivnosti krava. Rizik za pad produktivnosti kod krava koji borave na farmi sa lošim skorom dobrobiti i koje pokazuju lošu metaboličku adaptaciju je od 1,9 do 2,8 puta veći u odnosu na krave koje nisu izložene ovim spoljašnjim i unutrašnjim stresorima. Redukovanje stresora redovnim pregledom i korekcijom papaka, izradom metaboličkog profila i procenom metaboličkog statusa te aplikacijom različitih suplemenata u hrani omogućuje najbolji odnos između uloženi sredstava i dobiti koja se tom prilikom ostvaruje.

**Ključne reči:** krave, ocena dobrobiti, metabolički profil, proizvodnja mleka, servis period.

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