

The relationship between rearing system, animal needs index and dairy cows milk traits

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Abstract

This study was conducted in five dairy farms with different capacity (farms A with 47, B 12, C 10, D 14 and E 24 Simmental cows, aged between 4 and 5 years and body weight about 600 kg) in order to determine a relationship between rearing system, Animal Needs Index (ANI) and milk traits. Loose system of cow rearing was used in open stalls in farms A and C, while in other farms cows were tied in closed stalls. In two farms, there were outdoor pens, permanently available to cows on farm A, and during daytime on farm D. Rations for dairy cows were equal in all five farms and suitable for daily milk production about 20 kg with 4.0 % milk fat and 3.5 % milk protein. It was established that total ANI scores for farms were A 35.5, B 9.5, C 24.5, D 26.5 and E 10.5. The welfare levels in farms B and E were not sufficient, in farms C and D were very good, while in farm A it was excellent. A very significant influence of rearing system on cow welfare was found ($p < 0.001$). A significant influence of rearing system ($p < 0.01$) on average daily milk yield, milk yield in standard lactation, milk fat (kg), yield of 4 % fat corrected milk and yield of proteins (kg) were noticed. The influence of the rearing system on milk fat content (%), dry matter (%), protein (%) and lactose (%) was not statistically significant. Differences between ANI score, daily and standard lactation milk yield were very significant ($p < 0.001$), as well as differences between ANI and the amount of milk fat (kg), protein (kg) and amount of 4 % fat corrected milk.

Key words: dairy cows, milk traits, rearing system, welfare

Introduction

It is usually considered by breeders and professionals that rearing conditions influence production and traits of dairy milk. Investigations, however, point out that this influence is very complex, according to already reported controversies (Konggaard, 1977; Fregonesi, 1999; Mark and Lassen, 2007; Hovinen et al., 2009; Zlatanović, 2009; Simensen et al., 2010). Rearing conditions include tied or loose system and numerous spatial, microclimate and

hygienic factors (Hristov et al., 2006b) which are under great human influence. Mostly, their influence on dairy milk production and milk traits is not fully scrutinized (Çülek and Tekün, 2005), while relationship between rearing conditions and dairy cattle welfare is well recognized (Zlatanović, 2009; EFSA; 2012). In the last twenty years, cattle rearing conditions have been included in many complex methods of animal welfare assessment (EFSA; 2012; Hristov et al., 2012). One of them is ANI (Animal Needs Index), assessing the most important five

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animal welfare categories (Bartussek et al., 2000). In the last few years, researchers have analyzed relationship between rearing conditions and milk production, as well as their relationship to cows' welfare (Fregonesi and Leaver, 2001; Zlatanović, 2009; de Vries et al., 2011; EFSA, 2012). Investigation results point out complexity of these relations, primarily due to differences between tied and loose system of rearing, whereas if the same system is used, differences in spatial, microclimate and hygienic conditions are underlined and moreover, considered able to influence welfare and milk production of cows (Fregonesi, 1999; Ostojić-Andrić et al., 2011).

Bearing in mind that rearing conditions can affect the production of milk, recognizing the need to assess cow welfare in everyday practices and considering parameters which are observed in ANI, the goal of this paper was to assess and determine the relationship between system of cow rearing and welfare status using ANI, milk production and traits.

Material and methods

Investigation of rearing system effect on cow welfare and dairy milk traits was conducted in five farms of different size (farms A, B, C, D and E) with total of 107 Simmental cows, aged between 4 and 5 and body weight about 600 kg. There were 10 cows in the smallest farm (farm C) and 47 in the biggest (farm A), while farms B, D and E had 12, 14 and 24 cows, respectively. Loose rearing system was used in farms A and C, while in the other three farms cows were tied. In two farms there were outdoor pens, permanently available to cows in farm A and during daytime in farm D. In farm C loose system of rearing without outdoor pen was used. Farms B and E had older type stalls.

Daily rations for the cows' nutrition during lactation were equal in all five farms and consisted of 8 kg of alfalfa hay, 15 kg of corn silage, 6 kg of concentrate with 15 % of crude proteins, 0.1 kg of mineral-vitamin premix and 0.1 kg of salt.

To assess welfare of dairy cows in these farms ANI method of Bartussek et al. (2000) was used. This method includes the most important five animal welfare categories: 1. possibility of movement, 2. possibility of social contacts with other cows, 3. type and quality of floor, 4. lighting and air quality in the accommodation facility and 5. interaction of

stockman with cattle. The score of welfare levels in farms expressed as ANI was obtained after summarizing points for all welfare categories, which could range from -9 to +45.5 points.

Daily milk yield was measured directly after milking and standard lactation milk yield data for all cows were calculated. Chemical traits of dairy milk (content of proteins, milk fat, lactose and dry matter) were determined by Milkoscan 4000 (Foss Electric, Hillerød, Denmark).

For the given dairy milk traits, descriptive statistic parameters were calculated and milk yield correction for 4 % milk fat (% FCM - fat corrected milk) was accomplished by Gaines-Davidson's formula ($4 \% \text{ FCM} = 0,4M + 15F$; M - milk, F - fat).

Review of relationship of certain factors, such as the relationship between farm ($n = 5$), welfare level ($n = 3$), milk production and traits was performed by analysis of variance for monofactorial trial, while testing of significance was performed by LSD test. Influence of rearing system (loose or tied) was evaluated by Student's test.

Results and discussion

The obtained results from the investigation of the ANI categories inside five husbandry conditions and total ANI score in all five farms are given in Table 1.

It is obvious that the ANI parameter values were very different within all investigated five husbandry conditions in farms (Table 1), according to movement and locomotion (from 1.5 to 9), social interaction (from 2 to 7), type and conditions of flooring (from 1 to 4), stable climate which included light, air quality and noise (from 1.5 to 9.5) and stockman's care (from 3.5 to 6.5). Also, considerable differences between farms in total ANI score (from 9.5 to 35.5) were found.

According to established ANI results, all farms were divided in three groups, as it is given in Table 2. It was found that farms B and E were not suitable in respect of welfare (ANI 1), farms C and D were suitable in respect of welfare (ANI 2) and farm A was excellent in respect of welfare (ANI 3), according to the scale in the publication of Bartussek et al. (2000).

Table 1. ANI assessment on the farms

Farm	A	B	C	D	E
System of rearing	Loose, with outdoor pen	Tied	Loose, without outdoor pen	Tied, with outdoor pen during daytime	Tied
Number of animals	47	12	10	14	24
ANI parameters					
Movement and locomotion	9	1.5	5	4.5	2
Social interaction	7	2	4.5	5	2
Floor	4	1	3	3	1
Stable climate	9.5	1.5	5.5	8.5	2
Stockmanship	6.0	3.5	6.5	5.5	3.5
Total ANI score	35.5	9.5	24.5	26.5	10.5
Verbal welfare categories score	excellent	not sufficient	very good	very good	not sufficient

Table 2. Allocation of farms according established ANI

ANI groups	Farm	Total ANI score
ANI1 (N=36)	Farm B, tied (N=12) Farm E, tied (N=24)	<11
ANI2 (N=24)	Farm C, loose system of rearing without outdoor pen (N=10) Farm D, tied system of rearing with outdoor pen during day (N=14)	24.5-28
ANI3 (N=47)	Farm A, loose with outdoor pen (N=47)	>28

Table 3. Influence of rearing system on cow welfare (t-test)

Parameter	Loose system (N1=57)	Sd1	Tied system (N2=50)	Sd2	t-value
Total ANI score	2.82 ^a	0.384	1.28 ^β	0.454	19.081***

Legend: statistical difference marked with different letters: α , β - $p < 0.001$

Based on obtained results of dairy cow welfare assessment by ANI and existing level of welfare in farms with different type of rearing and different size, it is obvious that levels of welfare in dairy farms with tied system of rearing without possibility to use outdoor pens were not sufficient (farm B and E). The level of welfare was excellent in farm with loose system of rearing and permanent access to outdoor pens (farm A). Besides that, it could be noted that state of welfare in farm with loose system of rearing without use of outdoor pens was very good (farm C), as well as in tied system farm with daytime use of outdoor pens (farm D).

The influence of rearing system (loose and tied) on cow overall welfare expressed through total ANI score is shown in Table 3.

According to t-test results, a very significant influence of rearing system on dairy cow overall welfare expressed through total ANI score ($p < 0.001$; $t = 19.081$) was established. Obtained results point out that loose system of rearing was significantly better than tied system in respect to the cow welfare.

In Table 4 were given nutritional values of ration for dairy cows during lactation.

Table 4. Nutritional value of ration for dairy cows

Ration nutritional value	Amount
Dry matter intake, kg	17.7
Net energy for lactation, MJ	114.64
Metabolic protein, g	1803
Protein degradable in the rumen, g	1402
Protein undegradable in the rumen, g	761
Crude protein, % of dry matter	14.5
Neutral detergent fiber, % of dry matter	36.4
Acid detergent fiber, % of dry matter	26.6
Crude fat, % of dry matter	2.6
Total Ca, % of dry matter	1.1
Usable Ca, g	92.0
Total P, % of dry matter	0.5
Usable P, g	59.0
Usable K, g	230.0

Table 5. Influence of the system of rearing on milk traits (t-test)

Milk traits	Loose system, average values (N1=57)	Sd1	Tied system, average values (N2=50)	Sd2	t-value
Daily milk yield, kg	17.03 ^x	2.793	13.59 ^y	1.1977	8.082 ^{**}
MPSL, kg	5222.5 ^x	897.83	4125.1 ^y	380.27	8.034 ^{**}
Milk fat, %	4.01	0.173	4.04	0.148	-1.002 ^{n.s.}
Milk fat, kg	208.57 ^x	30.834	166.53 ^y	13.627	8.905 ^{**}
4 % FCM, kg	5217.6 ^x	816.21	4147.9 ^y	349.54	8.597 ^{**}
Dry matter, %	8.845	0.354	8.804	0.498	0.499 ^{n.s.}
Protein, %	3.341	0.319	3.435	0.381	1.396 ^{n.s.}
Protein, kg	228.54 ^x	41.032	198.015 ^y	40.745	3.852 ^{**}
Lactose, %	4.754	0.237	4.675	0.257	1.669 ^{n.s.}

Legend: statistical difference marked with different letters: x, y - $p < 0.01$

According to NRC (2001) nutritional value of daily ration for dairy cows (Table 4) meet requirements for 20 kg daily milk yield with 4.0 % fat and 3.5 % milk protein for cows with body weight 600 kg.

In recent years, interest for establishing the relationship between dairy cattle rearing systems, welfare and milk production has grown. Many investigations contributed to enhancement of dairy cattle welfare level as well as explanations of relationship between the welfare, behaviour, health status, rearing conditions and dairy milk traits (Fregonesi, 1999; Fregonesi and Leaver, 2001; Fregonesi and Leaver, 2002; Klopchich et al., 2007; Rushen et al., 2008; Zlatanović, 2009; de Vries et al., 2011; EFSA, 2012). However, there is no a lot of data on relationship between system of rear-

ing, welfare status expressed as ANI and milk traits (Zlatanović, 2009; Hristov et al., 2010) revealing their interdependence. It should indicated that ANI was developed to be used primarily on farm level as an instrument for assessing and grading livestock housing with respect to the well-being of the animals. Clearly, the ANI does not assess the full range of essential needs that the respective farm animals might possess. It assesses animal housing conditions on the basis of what is known to be the most important in meeting the animals' needs and ensuring their well-being (Bartussek et al., 2000).

Statistical analysis of the investigated parameters of milk traits depending on the cattle rearing system is shown in Table 5.

The data analysed by t-test showed significant influence of rearing system on average daily milk yield, milk production in standard lactation (MPSL), milk fat (kg), yield of 4 % fat corrected milk (4 % FCM) and yield of proteins in kilograms ($p < 0.01$, $t = 8.082$; $t = 8.034$; $t = 8.905$; $t = 8.597$ and $t = 3.852$, respectively). The system of rearing did not influence significantly on content of milk fat (%), as well as percentage of dry matter, protein and lactose.

There are few studies that take into account the specific aspects of housing conditions on milk production (Fregonesi and Leaver, 2002; Klopchich et al., 2007; Simensen et al., 2010). Almost 40 years ago, the impact of housing condition on milk production was investigated. Although at the beginning cows in the tie-stalls produced approximately 10 % more milk than the cows in the two loose housing systems; later the cows in the deep-bedded loose housing became the highest producers (Konggaard, 1977). Simensen et al. (2010) found that average milk production per cow-year was 134 kg lower in free-stall herd than in tie-stall herds, but in the range 27-45 cows there was no significant difference in yields between the herd categories. In herds with less than 27 cows, there were increasingly lower yields in free-stalls, whereas the yields were increasingly higher in free-stalls with more than 45 cows. The finding that milk production per cow-year was lower in loose systems is in agreement with results from previous studies in Norway (Bakken et al., 1988; Østerås, 1990) and Finland (Hovinen et

al., 2009). Hovinen et al. (2009) found that cows in tie stalls had higher milk yield (28.5 ± 0.29 kg/d) than cows in loose housing barns (26.5 ± 0.46 kg/d). Several reasons could explain this finding, including more successful individual feeding of the cows in the tie-stall barns. However, Mark and Lassen (2007) in a large-scale study in Denmark found no difference in milk yield between cows in tie stalls and those in loose housing.

Obtained data (Table 5) clearly showed that production of milk, milk fat (kg) and protein (kg) was higher in loose dairy farms. This may be associated with better housing conditions and the state of well-being of cows.

According to Sutton (1989) and Brun-Lafleur et al. (2010), nutrition is crucial factor in dairy cows production, which may influence significantly on milk yield and fat content but dietary protein has only small effects on either milk fat or protein concentration. Milk fat can be changed by 0.1 to 1.0 percentage points, while protein is seldom altered more than 0.1 to 0.4 points by nutritional changes. Very small changes in lactose concentration occur sometimes in response to diet but they are inconsistent and not of practical value. Coulon and Remond (1991) concluded that the protein content response to energy supply was linear whatever the stage of lactation. Variations in milk yield and in milk protein content is curvilinear, depending on the stage of lactation and on the level of feeding proportional to the energy requirements.

Table 6. Mean values and standard variations of milk traits in respect of ANI

Parameter	ANI groups		
	ANI1	ANI2	ANI3
Number of cows, n	36	24	47
Average daily milk yield, kg	$13.35^a \pm 0.198$	$16.50^b \pm 0.687$	$16.45^b \pm 0.359$
MPSL, kg	$4046.86^a \pm 63.71$	$5085.00^b \pm 229.56$	$5025.74^b \pm 110.09$
Average milk fat content, %	4.05 ± 0.027	4.00 ± 0.025	4.01 ± 0.025
Average milk fat content, kg	$163.98^a \pm 2.29$	$203.12^b \pm 8.59$	$200.77^b \pm 3.60$
4 % FCM, kg	$4078.56^a \pm 58.48$	$5080.87^b \pm 220.24$	$5021.95^b \pm 97.27$
Milk protein content, %	3.45 ± 0.062	3.35 ± 0.072	3.35 ± 0.048
The amount of protein in the standard lactation, kg	$185.9^a \pm 5.92$	$250.1^b \pm 8.53$	$217.7^c \pm 5.07$
Lactose, %	4.66 ± 0.039	4.77 ± 0.052	4.73 ± 0.036

Legend: statistical difference marked with different letters: α , β , γ - $p < 0.001$

Mean values and standard variations of milk traits in respect of established ANI in the farms are given in Table 6.

According to presented data (Table 6), cows from ANI1 group had statistically lower average daily milk yield, MPSTL, milk fat content (kg) and quantity of 4 % FCM comparing to cows of groups ANI2 and ANI3. In addition, the amount of protein in the standard lactation differed among all compared groups.

Generally, milk yield in registered Simmental cows in Serbia ranges from 4000 kg to 5000 kg milk in standard lactation, depending on the lactation and geographical region (Perišić et al., 2009). According to Bogdanović et al. (2007), the average milk production of recorded cows of the Simmental breed in small Serbian farms is about 4200 kg (fat 3.91 %). Results of Nikšić et al. (2011) showed average milk production of 4348 kg, milk fat content of 3.93 % and milk fat yield of 171.1 kg and a moderate trend of increase in milk performance in the first calving cows.

In the study of Budimir et al. (2011) in Bosnia and Hercegovina, Simmental breed cows had average milk production in the first lactation of 4084 kg, in the second 4440 kg and in the third 4483 kg in very bad conditions of feeding and rearing, meaning that there is genetic potential and the possibility of more efficient utilization and of increasing production of milk.

In relation to the chemical composition of milk, Klopčich et al. (2007) found that milk of cows from loose system had significantly higher ($p < 0.001$) protein content comparing to the tied system. The same authors established that cows from loose stalls produced significantly ($p < 0.001$) more milk than those from tied stalls. In addition, Janžekovich and Rozman (2006) found that average milk production per cow increased by 6 % after transition from tied to loose housing stall, while fat and protein content did not change significantly. Also, they found the lower protein content in tied system during summer months, which could be explained by time limitation of grazing (8 hours) comparing to the loose system (not timely limited). Consequently, the consumption of dry matter was lower in tie system, which contributed to lower milk production and protein content. Lactose content was higher in

loose housing system (4.62 %) compared to tied system (4.50 %).

According to obtained data, it could be noticed that welfare and production state on observed farms, especially those with older stalls and smaller number of cows (farms B and E), are results of adaptation of the farmers to current resource potentials and without long term planning (Hristov et al., 2006a; Hristov and Stanković, 2009).

The results of investigation may provide an effective characterization of cows, and based on these results, recommendations for improving technology of dairy population may be proposed, as it was emphasised by Festila et al. (2011). Improving environmental conditions and management practices with improved genetic potential of dairy animals would be more effective approach to increase milk production (Gerber et al., 2007).

Production in Serbian farms is often unprofitable, and welfare standards are not applied completely. Technology of production is often outdated; when building or reconstructing accommodation facilities, farmers are not guided by new scientific and professional knowledge (Hristov et al., 2006a; Hristov and Stanković, 2009). There are some attempts to improve technology of dairy production by some cattle farmers in Serbia, but in the most of cases it happens randomly and without complete implementation of welfare standards. Mostly, they install modern equipment in stalls and milking parlours, but that does not mean automatically better conditions for cows and milk production improvement. Farmers are not properly informed about physical and psychological needs of animals, not only from ethical point, but in respect of consequences for health status and productivity, as well. For instance, many stockmen do not take into account the impact of the lack of movement, poor microclimate conditions and inappropriate floors in the stall on cows' health and welfare. Furthermore, farmers are often not aware of importance of certain biosecurity measures (Hristov et al., 2006a; Hristov and Stanković, 2009; Hristov et al., 2010; Hristov et al., 2012). Similar situation regarding welfare of dairy cattle could be found in other developing and developed countries (FAWC, 2009; EFSA, 2012).

Determination, understanding and interpretation of the obtained ANI value for each category

on the farm may have a decisive importance. In addition, in order to make evaluation by ANI system operational, it is necessary to introduce minimum standards for housing conditions in domestic breeding practices, which combined with some minimal corrections of grading systems, raising awareness of breeders and other adjustment measures, would improve cattle production performance and competitiveness on the world market.

Conclusions

According to presented and analyzed data, the investigation revealed significant influence of rearing system ($p < 0.01$) on daily milk yield, MPSL, 4 % FCM, milk fat and protein yield. Nevertheless, system of rearing did not affect the content of milk fat, protein, lactose and dry matter ($p > 0.05$).

Relationships between ANI score and both daily and standard lactation milk yields were very significant ($p < 0.001$). Also, relationships between ANI score and the amount of milk fat (kg), protein (kg) and the amount of 4% fat corrected milk (kg) were very significant ($p < 0.001$). Influence of farm type on milk fat content, protein, lactose and total solids in milk was not significant ($p > 0.05$).

The research clearly shows that better milk production results were achieved in farms with higher ANI scores. In addition, better results were achieved with loose housing systems in farms with outdoor pens. It could be emphasized significant influence of system of rearing ($p < 0.01$) on daily milk yield, MPSL, 4 % FCM, milk fat and protein yield.

Most ANI points were given for farms with loose system, so relation between system of rearing (loose and tied) and welfare of cows on farms showed significance ($p < 0.001$).

Based on the presented results can be stated that it is necessary and possible to find solutions for farms in order to correct and improve housing conditions for all ANI categories.

Determination, understanding and interpretation of the obtained ANI value for each category on the farm may have a decisive importance, which combined with some minimal corrections of grading systems, raising awareness of breeders and other adjustment measures, would improve cattle production performance.

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Odnos sustava držanja, indeksa potreba životinja i osobina kravljeg mlijeka

Sažetak

Istraživanje je provedeno na pet farmi muznih krava simentalke pasmine različitog kapaciteta (farme A 47, B 12, C 10, D 14 i E 24 krave; starost krava se kretala od 4 do 5 godina, tjelesne mase od oko 600 kg) s ciljem da se utvrdi odnos sustava držanja, indeksa potreba životinja i osobina mlijeka. Na farmama A i C s otvorenim stajama korišten je slobodan sustav držanja, dok su na ostalim farmama krave držane vezano u zatvorenim stajama. Na dvije farme postojali su ispusti, stalno dostupni kravama na farmi A, a tijekom dana dostupni na farmi D. Dnevna sljedovanja za mliječne krave bila su ista na svih pet farmi i zadovoljavala su potrebe za dnevnu proizvodnju 20 kg mlijeka sa 4 % mliječne masti i 3,5 % mliječnog proteina. Istraživanjima su utvrđene ANI vrijednosti na farmama: A - 35,5, B - 9,5, C - 24,5, D - 26,5 i E - 10,5. Utvrđeno je da je razina dobrobiti na farmama B i E nedovoljna, na farmama C i D vrlo dobra, a na farmi A odlična. Utjecaj sustava držanja na dobrobit krava bio je vrlo značajan ($p < 0,001$), a na količinu pomuzenog mlijeka, količinu mlijeka u standardnoj laktaciji, sadržaj mliječne masti (kg), sadržaj 4 % korigirane mliječne masti i sadržaj proteina (kg) značajan ($p < 0,01$). Utjecaj sustava držanja na sadržaj mliječne masti (%), suhe tvari (%), proteina (%) i laktoze (%) nije bio značajan. Razlike između ANI ocjena, dnevnih količina mlijeka i količina pomuzenog mlijeka u standardnoj laktaciji bile su vrlo značajne ($p < 0,001$), kao i razlike između ANI i količina mliječne masti (kg), proteina (kg) i količine mlijeka korigiranog na 4 % mliječne masti.

Ključne riječi: mliječne krave, osobine mlijeka, sustav držanja, dobrobit

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