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Gonadal differentiation in *Vimba vimba* (L. 1758)

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ABSTRACT: Gonadal differentiation was studied in the anadromous cyprinid fish – vimba (*Vimba vimba* L. 1758). We obtained the study material by artificial spawning of fish from Ostrowieckie Lake, NW Poland. Embryos were reared at $25.0 \pm 0.5^\circ\text{C}$ in a recirculation system and fed *ad libitum* on *Artemia* sp. The analysis of cytological and anatomical sex differentiation was conducted by taking samples every 14 days after hatching. The first symptoms of morphological differentiation appeared on the 57th day after hatching with an average total body length (*longitudo totalis*) of 3.6 cm and an average weight of 0.33 g. Spindle-shaped gonads were observed attached to the peritoneum on both sides (future ovaries) and pear-shaped gonads attached with a single mesentery string (future testes). On the 71st day after hatching the first female-line cells – oogonia appeared, with the diameter range from 26.5 to 33.1 μm . Spermatogonia were observed much later, on the 228th day after hatching. The final shaping of the gonads' macroscopic structure took place earlier in females (142nd day after hatching) than in males (288th day after hatching).

Keywords: *Vimba vimba*; gonadal differentiation; oogonia; spermatogonia; Odra basin

Vimba (*Vimba vimba* L. 1758) inhabits the catchment areas of the Caspian, Black and Baltic Seas and eastern part of the catchment area of the North Sea. Although the Laba and Wezera rivers mark the western border of its range, individuals were observed in the rivers of France and Holland (Cazemier and Heesen, 1989; Schweyer *et al.*, 1991). In the waters of Poland vimba is the only cyprinid fish that performs anadromous breeding migrations. However, in the previous several dozen years a decrease in ichthyofauna structure and a constant increase in the number of species threatened with extinction were observed in Poland (Heese and Witkowski, 1996). The decrease in the fish number and the proceeding decline of autochthonic rheophil species with high environmental requirements, among which vimba is included, is caused by the influence of poor water quality, loss of free flow rivers, poaching and irrational fishery administration (Penczak and Mann, 1993; Witkowski, 1996; Witkowski *et al.*, 1999). These factors caused a decrease in vimba's breeding mi-

grations in the Vistula and Odra systems and a destruction of its natural habitats and spawning grounds. As a consequence of these changes the species began to decline. The process intensified in the 70s and 80s and reflected in a significant decrease in commercial catch of vimba (Wiśniewolski, 1987; Backiel and Bontemps, 1995; 1996). At present, vimba is considered critically endangered (Witkowski *et al.*, 1999) and as such has been included in a project of migratory fish restoration, together with its freshwater form (Sych, 1996). In recent years in Poland the vimba, which was on edge of extinction, was restocked in the Odra River system (Hliwa *et al.*, 2000; Kleszcz *et al.*, 2001) and successfully restituted (Witkowski *et al.*, 2001).

We investigated the course of anatomical differentiation of gonads in vimba, on the basis of determination of their shape and macroscopic structure (i.e. laminas in ovaries and seminal vesicles in testes), as well as cytological differentiation, consisting in specialization and differentiation of characteristic germ cells.

MATERIAL AND METHODS

Gonadal differentiation in vimba was examined in 1999–2000. Spawners (11 females and 9 males at the age from 5+ to 7+) were collected in Ostrowieckie Lake, the largest reservoir in Drawieński National Park (NW Poland) using gill nets with various mesh sizes from 25 to 55 mm. Average body length (*longitudo corporis*) of the spawners was 24.9 ± 2.45 cm and average weight was 239.4 ± 93.6 g. The spawners were held in 0.5 m^3 tanks supplied with oxygenated water and a temperature of $19.0 \pm 0.5^\circ\text{C}$. Ovulation and spermiation were induced by injecting Ovopel in doses 1 (females) and 0.2 (males) pellet per kg of body weight. One dose of Ovopel included 18–20 μg mammalian's analogue GnRH (D-Ala⁶, Pro⁹Net-mGnRH) and 8–10 mg dopamine inhibitor – metoclopramid. Spawning occurred 36 hours after hormonal stimulation that was made May 30th. Vimba larvae were raised at a constant water temperature of $25.0 \pm 0.5^\circ\text{C}$, in a recirculation system and fed *ad libitum* *Artemia* sp. After the second month of rearing, *Artemia* sp., frozen zooplankton and commercial Aller Møller feed were used for food.

For the histological analysis, 7 individuals were sampled at random every 14 days, during the nine months period of rearing. The fish were measured (*longitudo totalis* – TL) (± 0.5 mm) and weighed (± 1.0 mg). The collected material for histological analysis was fixed in Bouin's solution. Subsequently

the specimens were dehydrated in alcohol with increasing concentration, fixed in xylene and left intact for paraffin embedding. The sections were cut into pieces 5 μm thick and stained with the HE method (Mayer's haematoxylin and eosin) (Zawistowski, 1986). The serial cross-sections were analysed for the shape, size, blood flow, and the type of germ cells present in gonads. The cell diameters were measured ($\pm 1.0 \mu\text{m}$) under a microscope using MultiScanBase v. 13.01 classical micro image computer analysis software for WINDOWS (Computer Scanning Systems, Ltd., Warsaw, Poland).

RESULTS

The initial average weight of vimba larvae was 0.01 ± 0.01 g, and the total length was 1.3 ± 0.1 cm. After 288 days the fish attained an average body weight 4.21 ± 0.63 g and average TL 8.3 ± 0.37 cm (Figure 1).

During individual development, sex cells were observed next to and along the swim bladder. They were even and symmetrically located on both sides of the bladder. In the first two tests, 15th and 29th days after hatching, no significant differences in the gonadal anatomical and cytological structure were observed. Only a large quantity of somatic cells and single (2–6) primordial germ cells (PGC) could be seen on all of the analysed sections (Figure 2A). Compared to somatic cells, PGC were large, round

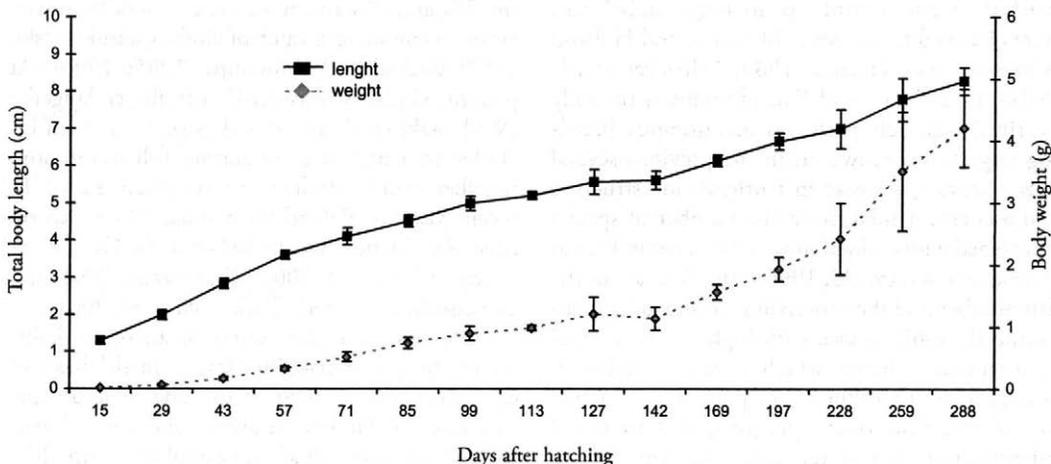


Figure 1. The growth of total length and weight of vimba in rearing conditions

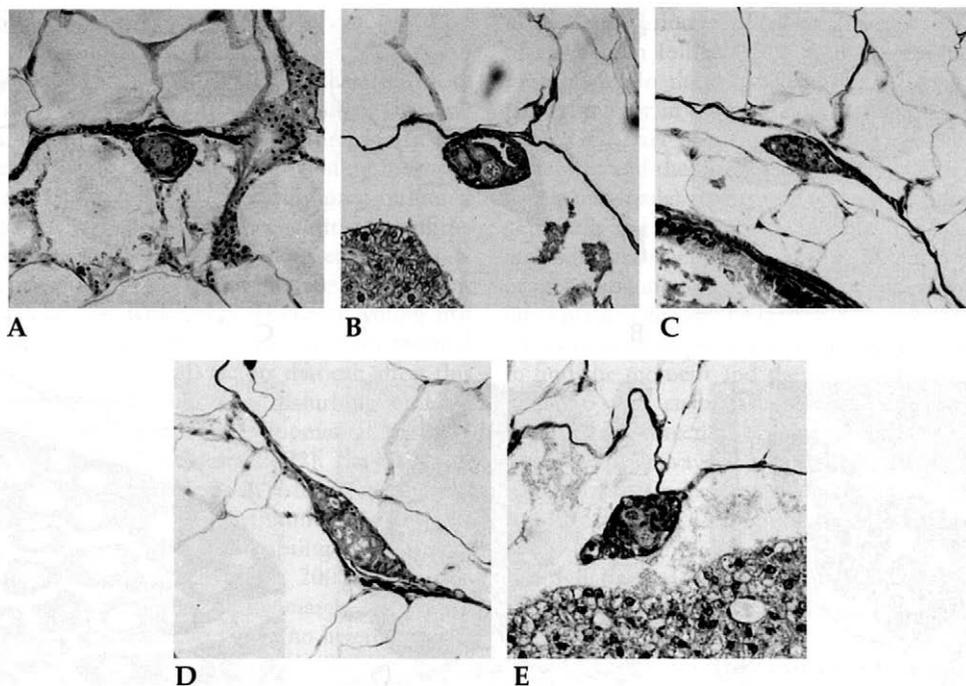


Figure 2. Histological sections of gonads: A – one primordial germ cell in the gonadal anlagen (29th day after hatching); B – spindle-shaped gonad attached to the peritoneum on both sides (57th day after hatching); C – pear-shaped gonad attached with a single mesentery string (57th day after hatching); D – ovaries of vimba with oogonia (71st day after hatching); E – pear-shaped gonad with two primordial germ cells (71st day after hatching). Magn. 460 \times

cells with an average diameter of $16.1 \pm 2.8 \mu\text{m}$, a marked border between the cytoplasm and somewhat eccentrically located nucleus. The nuclei of these cells stained with Mayer's haematoxylin more intensively than the cytoplasm.

On the 43rd day after hatching an increase in the number of primordial germ cells in the gonads was observed, as well as in the test made on the 57th day where PGC and gonocytes were found. The gonocytes were $13.4 \pm 2.2 \mu\text{m}$ in diameter. Two types of gonads could be seen on histological sections of the examined fish: spindle-shaped ones attached to the peritoneum with mesentery on both sides (Figure 2B) and pear-shaped ones attached with a single mesentery string (Figure 2C).

On the 71st day the fish were sampled, weighed ($0.52 \pm 0.08 \text{ g}$) and measured ($4.1 \pm 0.23 \text{ cm}$). The spindle-shaped gonads were observed on cross-sections of two individuals, with distinctly marked mitotic division of gonocytes. Single oogonia appeared in two specimens for the first time (Figure 2D). The oogonia were on average $29.7 \pm$

$4.1 \mu\text{m}$ in diameter. The volume of germ cells increased compared to the former tests and the multiplication of gonocytes and formation of oogonia, characterizing the first stage of the ovaries maturity, was observed. The appearance of oogonia terminated the indifferent period. In the pear-shaped gonads only primordial germ cells of unchanged number were visible (Figure 2E). Similar situation was observed in the next two tests – on the 85th and 99th day after hatching.

On the 127th day after hatching the average weight was $1.21 \pm 0.27 \text{ g}$ and average TL was $5.6 \pm 0.33 \text{ cm}$. Significant changes were observed in the appearance of the ovary germs. The gonads changed their shape from spindle-shaped to oval (sulcus). It was also possible to see the main vessels, located along the back. Two individuals had previtellogenic oocytes (Figure 3A) in their gonads. In the gonads of other three specimens further mitotic divisions of gonocytes and single oogonia were observed, with distinctly visible chromatin and enlarged volume of nucleus compared with the volume of

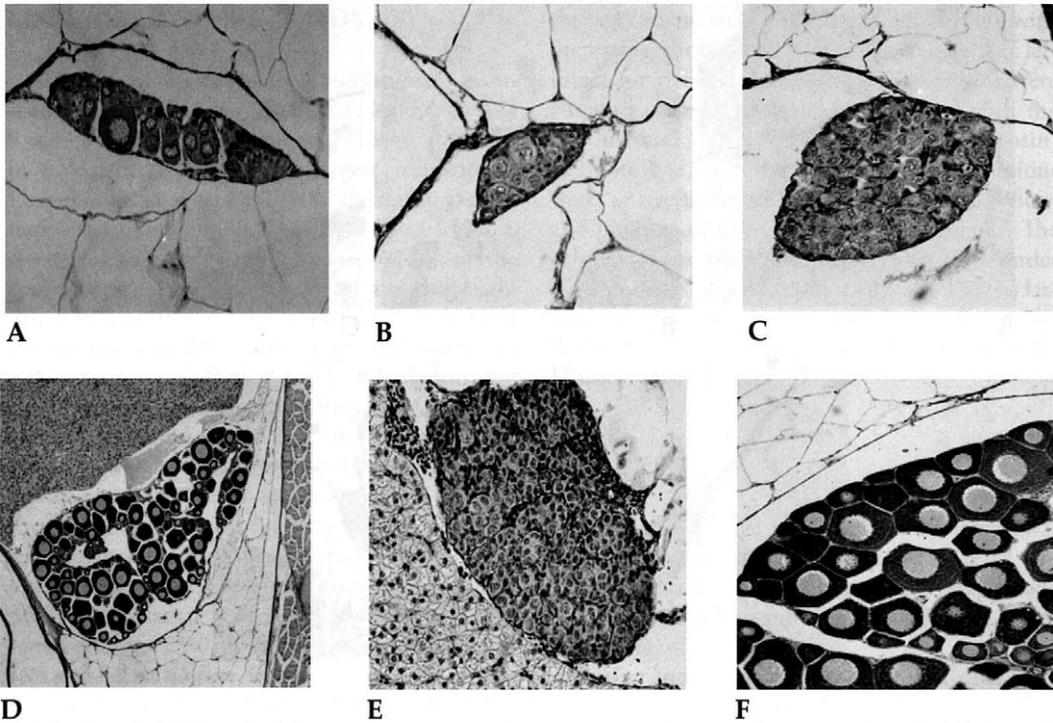


Figure 3. Histological sections of gonads: A – ovaries with previtellogenic oocytes (127th day after hatching, magn. 420 \times); B – pear-shaped gonad with gonias and primordial germ cells (127th day after hatching, magn. 420 \times); C – testes with spermatogonia (228th day after hatching, magn. 420 \times); D – ovaries with ovarian lamellae filled with previtellogenic oocytes (228th day after hatching, magn. 380 \times); E – ovaries of vimba (288th day after hatching, magn. 300 \times); F – testes of vimba filled with spermatogonia located in seminal vesicles (228th day after hatching, magn. 300 \times)

the interphase nucleus. The remaining specimens in the sample had pear-shaped gonads with the first mitotic divisions of primordial germ cells and gonocytes visible (Figure 3B).

In the histological sections of gonads of individuals examined on the 142nd day after hatching, a number of fundamental changes were seen. In the sulcus-shaped gonads apart from oogonia, previtellogenic oocytes were visible. They were large cells with a broad band of homogeneous cytoplasm that evenly stained with haematoxylin. The average cell size was $140.7 \pm 32.6 \mu\text{m}$. In the gonads with attached single mesentery strings that enlarged their volume considerably an increased number of mitotic divisions of PGC was observed, as well as gonocytes.

The same situation was observed in the samples taken on the 169th and 197th days after hatching,

but on the 228th day, more developed symptoms of gonadal differentiation were observed. Two individuals with pear-shaped gonads, apart from single primordial germ cells, also developed the spermatogonia (Figure 3C). Spermatogonia were relatively smaller ($14.3 \pm 3.6 \mu\text{m}$ average size) than oogonia, with a nucleus located centrally and surrounded by a narrow band of cytoplasm. Other female individuals had the sulcate ovaries containing oogonia and previtellogenic oocytes (Figure 3D).

On the 228th day after hatching the ovaries had an enlarged volume and were completely filled with previtellogenic oocytes (Figure 3E). The follicular cells appeared on the edges of the oocytes. The pear-like testes were filled with spermatogonia, located in seminal vesicles (Figure 3F).

DISCUSSION

Morphological sex differentiation characteristic of the most primitive multicellular animals is associated with the genetic material of the parents. The development of fish embryos (including means of sex determination) is theoretically predetermined by genetic factors and includes sensitisation of the bipotential gonads to endogenous endocrine factors prior to, during and even after commitment to maleness or femaleness. However, young fish are relatively vulnerable to a host of environmental (physical and chemical) factors that can affect this endogenous endocrine axis, disturbing or even overriding the putative developmental pathway (Strüssmann and Nakamura, 2002). The lability of sex-determination systems in fish increases sensitivity of some species to environmental pollutants capable of mimicking or disrupting sex hormone actions (Devlin and Nagahama, 2002). Sex chromosomes were found in approximately 10% of the examined fish species, in vimba no heteromorphic sex chromosomes were detected (Rabova *et al.*, 2003). The phenotype sex, i.e. male or female reproductive system, is “attained” by the fish in the later period of individual development, typically in the first weeks or months after hatching. The gonad germs look alike in both sexes. After the penetration of primordial germ cells into the gonads, we can observe the differences in the size and shape of the sex glands that appear gradually, as well as the differences in vascularisation and localization of the PGC (Demska-Zakęś, 1995). At the next stage the proper shape of the gonads is formed and sex-characteristic structures arise, i.e. laminae in the ovaries and seminal vesicles in the testes. The characteristic feature of sex differentiation in fish is that the anatomical differentiation of gonads usually takes place first and precedes the cytological one, which includes the sexualisation of germ cells and specialisation of the cells composing the somatic part of the gonads, e.g. gland cells. The anatomical differentiation is strictly related to quantitative changes, consisting above all in an increase in the number of germ cells (as a result of mitotic division) and epithelial cells (Bieniarz and Epler, 1991).

Persov (1975) reported that the primordial germ cells were present from the earliest stage of embryonal development to the beginning of their first mitotic divisions. The author also stated that only the PGC originated other sex cells, but Khoo (1979) claimed that sex cells could also be formed

in the later period of ontogenesis (e.g. from cells of epithelium folliculi as a result of their metamorphosis). In the case of vimba the PGC were located mainly in the central part of gonad germs. The PGC, after numerous divisions, evolve into gonocytes and then into oogonia (female) or spermatogonia (male). The period when the primordial germ cells and gonocytes are present in the gonads is defined as an indifferent period. When oogonia or spermatogonia appear, cytological differentiation takes place (Długosz, 1994).

It is a matter of great importance for pisciculture to find the moment and the course of sex differentiation as it enables the breeder to determine the desirable direction of gonadal differentiation. There exist two ways of manipulating the differentiation: by thermal stimulation (Patiño *et al.*, 1996; Strüssmann *et al.*, 1996) and by steroid substances used in bioengineering techniques and hormonal manipulations (Chan and Yeung, 1983; Hunter and Donaldson, 1983; Malison *et al.*, 1986; Demska-Zakęś *et al.*, 2000).

The differences in the structure of gonads are determined by age or size (Davies and Takashima, 1980; Malison *et al.*, 1990; Demska-Zakęś, 1994; Demska-Zakęś and Zakęś, 1995). In most teleost fish species the rate of mitotic divisions of PGC and gonocytes is higher in the gonads differentiating in the “female direction”. As a result, the fish of the same age, same weight or body length have the future ovaries of a larger volume than the future testes. The observation was made by Demska-Zakęś (1994) regarding hybrids of peled and whitefish (*Coregonus peled* × *Coregonus lavaretus*) and by Demska-Zakęś *et al.* (1998) regarding the asp. A similar situation was noticed during the observation of gonadal differentiation in vimba. The first differences in the structure of male and female gonads appeared on the 57th day of rearing, and they differed from each other with respect to their shape (spindle-shape and pear-like), size (female gonads were bigger), means of attachment (double in females, single in males) and quantity of vessels. Anatomical sex differentiation of tench occurred earlier, on the 24th day after hatching (females) and around the 41st day (males) (Długosz *et al.*, 1983). The first symptoms of anatomical sex differentiation of asp appeared on the 65th day from hatching (Demska-Zakęś *et al.*, 1998). The fold originating from the sex layer was not transformed at all in the individuals developing in the male direction. In the future females the edge of the fold was folded up

and coalesced with the peritoneal epithelium. As a result two types of gonadal structure could already be observed at the early stage of ontogenesis. The final formation of the macroscopic structure of ovaries occurred much later than in vimba's case, on the 245th day. In this period the ovaries changed their shape from spindle-shape to sulcate one. From the 288th day of rearing laminas of ovaries filled with germ cells appeared in oviducts. In the asp, seminal vesicles characteristic of testes appeared on the 310th day after hatching (Demska-Zakęs *et al.*, 1998).

The first symptoms of cytological differentiation in vimba females were observed on the 127th day after hatching, yet the males could be identified cytologically in about 228 days after hatching. This confirms the opinion of Hunter and Donaldson (1983) that the process begins earlier in homogametic individuals in the case of female vimba. A similar result was observed in tench and asp. Such cytological elements were observed in tench on the 111th day after hatching in females and on the 151st day in males, when the body length was from 3.2 cm to 6.9 cm and weight was from 0.6 to 5.5 g (Długosz *et al.*, 1983). The cytological differentiation of asp females took place on the 171st day when the first oogonia were visible, while in males it happened on the 268th day after hatching (Demska-Zakęs *et al.*, 1998).

Comparing the ways and the course of sex differentiation of a few species one must notice that the process was observed in various thermal conditions, usually close to the optimal level for a particular species. In the case of vimba it was a temperature of $25.0 \pm 0.5^\circ\text{C}$. For this species inhabiting inland waters, the temperature of 25°C could be near optimal for the development of rearing conditions of larval and juvenile stages (Wolnicki, 1996).

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ABSTRAKT

Diferenciace gonád u *Vimba vimba* (L. 1758)

U anadromních kaprovitých ryb druhu podoustev nosatá (*Vimba vimba* L. 1758) byla sledována diferenciace gonád. Materiál byl získán pomocí umělého výtěru v jezeře Ostrowieckie v SZ Polsku. Odchov embryí, která byla krmena *ad libitum* artemiemi (*Artemia* sp.), probíhal v recirkulačním systému při teplotě $25,0 \pm 0,5^\circ$ C. Analýza cytologická a anatomická diferenciace pohlaví byla prováděna na vzorcích jedinců odebíraných každých 14 dní po

vylíhnutí. První příznaky morfologické diferenciacce se objevily 57. den po vylíhnutí, kdy průměrná celková délka těla (*longitudo totalis*) činila 3,6 cm a průměrná hmotnost dosahovala 0,33 g. Vřetenovité gonády byly na obou stranách zavěšeny k peritoneu (budoucí vaječnice) a hruškovité gonády byly zavěšeny pomocí jednoho mezenteria (budoucí varlata). První samičí buňky - oogonia s průměrem od 26,5 do 33,1 μm se objevily 71. den po vylíhnutí. Spermatogonia byla zjištěna mnohem později, tzn. 228. den po vylíhnutí. Ke konečnému utváření makroskopické struktury gonád docházelo dříve u samičích jedinců (142. den po vylíhnutí) než u samčích jedinců (288. den po vylíhnutí).

Klíčová slova: *Vimba vimba*; diferenciacce gonád; oogonia; spermatogonia; povodí Odry

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Prediction of daily milk fat and protein content using alternating (AT) recording scheme

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ABSTRACT: A possible introduction of AT recording scheme instead of the currently used reference A4 method was studied on twelve farms in Slovenia. During the usual production control, milk yields were recorded for the evening (PM) and morning (AM) milking. The correlations between AM, PM and daily measurements were calculated and the equations for the evaluation of daily content of milk fat and proteins were tested. All the observed phenotypic correlations were significant, ranging from 0.578 (PM – AM) for fat and 0.987 (DPC – PM) for protein content. Coefficient of determination (R^2) for fat content ranged between 78.83% and 81.35% for PM, and 69.26% and 73.73% for AM for the tested models. For protein content, R^2 ranged from 97.47% to 97.65% for PM and 95.48% to 95.74% for AM. The differences between models were small and insignificant. However, the complex models reduced bias in extreme values.

Keywords: cattle; alternating AM – PM recording scheme; fat content; protein content

Milk recording gives cattle breeders regular information on milk yield and milk composition for each dairy cow in the herd. The results help breeders in herd management and represent the basic source of information for the prediction of breeding value. In Slovenia, milk recording is performed according to A4 reference method, which is also considered as the most expensive one. A small number of cows per herd (on average 12.1 cows) and relatively long distances between farms in Slovenia make it even more expensive, therefore the costs of this method of recording per cow are much higher compared to other countries. High costs need to be reduced by a rationalized milk recording scheme. Rationalization could be possible with the introduction of the alternate (AT) recording scheme according to ICAR guidelines (2003).

Protein and fat content are the most important components that dictate the purchase price of milk. They are influenced by various genetic as well as environmental factors, such as nutrition, stage of lactation, age of the animal, season, climatic effects, milking system, milking time, udder health, etc.

Fat content is the most variable component of milk and besides the factors listed above, also depends on completeness of milking, sampling

procedure and milking interval. Huth (1995) reported that a longer milking interval from one to five hours significantly increases fat content and decreases milk yield one day later. In such cases, the increase in fat content is expected.

Protein content does not vary to the same extent as fat content. Energy supply has the strongest impact on the protein content. Sufficient energy supply enables maximal synthesis of proteins in the rumen, representing as much as 60 to 80% of all proteins that digest in the small intestine (Hanuš *et al.*, 1995). In Slovenia, the highest decrease in protein content is noticed in periods with low energy supply that occur in late spring and summer. Most udder illnesses like mastitis and high somatic cell count are present during these periods. Besides the lower protein content, they also worsen protein composition. Longer milking intervals do not change protein content as much as fat content (Huth, 1995).

Phenotypic correlations in milk composition between daily and evening or morning milking are mostly high, more than 0.89 (Lee and Wardrop, 1984; Zierer *et al.*, 1995; Gernand, 1998; Liu *et al.*, 2000). Trappmann *et al.* (1998) found a high correlation for fat ($r \cong 0.90$), and an even higher

correlation for protein content ($r > 0.96$). The same trend was observed by other authors. In protein content, the highest phenotypic correlations (0.96–0.98) were found in the comparison of daily (DPC) and morning (AM) samples. Similar correlations were observed between daily and evening (PM) samples (0.94–0.98). The lowest correlations were established for the evening (PM) and morning (AM) milking, where the authors reported correlations between 0.82 and 0.95.

Phenotypic correlations for fat content were lower compared to protein content. The lowest correlations were determined between evening (PM) and morning (AM) measurements (0.49–0.63). The highest fat content correlations were determined between the daily (DFC) and morning (AM) milking (0.83–0.92). Slightly lower correlations were found between daily and evening milk fat content.

The main objective was to develop and to test a simple, but robust model for daily milk fat and protein content of recorded cows. We wanted to find out whether the AT recording scheme would provide sufficiently accurate predictions of daily fat and protein content for management and selection purposes.

MATERIAL AND METHODS

The experiment was carried out from October 1998 to December 2000 on twelve farms in Gorenjska region. Milk recording was performed by three supervisors according to the recommendations for A4 and AT4 (ICAR, 2003). Each supervisor visited four farms. On two farms there were milking parlours, on five farms milk pipelines were used, and on the other five farms they milked to a jar. Besides, the farms differed in their production systems: two had free-range production, on the other ten farms the cows were tied. On five farms the cows were on the pasture during the summer season. In our experiment, 58% of measurements were taken from Simmental cows and 39% from Holstein Friesian cows. Less than 3% of measurements were taken from cows of different crosses (Table 1).

Altogether 4 070 daily records were taken. At each recording, milk yield was measured in the evening and in the morning. Three samples were taken from each cow: each separately for evening and morning milking, together with a proportional composite milk sample that was taken for regular

recording. All three samples were analysed in the Veterinary Laboratory Kranj in three replications. Milk was analysed on Milko-Scan 4000 (Foss Electric, Denmark) by the infrared spectroscopy method when milk composition was determined. Using reference methods, milk protein content in per cent is given in terms of the content of so called crude protein, i.e. total nitrogen (according to Kjeldahl method) $\times 6.38$, and weight percentage (g/100 g) of the fat according to Röse-Gottlieb method. For the calculation of milking interval, the time at the beginning of the evening and morning milking was recorded.

On average, 19 cows per farm were in test, and 340 measurements were taken per herd. The majority (21%) of measurements were carried out on farm 1 where most cows (48) were tested, while on farm 4 only 3% of measurements were taken for 10 recorded animals. Considering each month the number of measurements was more or less equal (around 350 measurements), with the exception of July and August, when a lower number of measurements was due to the supervisors' summer leave. The age of tested cows was quite different, ranging from heifers to cows in the 10th lactation. Almost 30% of all the measurements were taken from cows in the 1st lactation, 21% in the 2nd, 15% in the 3rd, and 13% in the 4th lactation. The other 22% were taken from older cows. The experiment lasted for three years and the cows had already finished at least two lactations, therefore the measurements were equally distributed regarding the stage of lactation. As much as 90% of all the measurements were taken in the first ten recordings, in the first 305 days after calving.

The results of milk analysis were entered into database at the Zootechnical Department of the Biotechnical Faculty. After validation, data that did not correspond to the logical control for milk components (fat, protein) or milk yield, recommended by ICAR (2003), were excluded. In addition, those records that were taken at one milking only, e.g. cows at the end of lactation due to drying, were removed. Some illnesses, injuries or mortality occurred. Altogether, 185 measurements were discharged.

Slightly higher values in milk composition were observed in evening milking (Table 1). The milking interval during the night was 2 minutes longer compared to the day interval (Klopčič *et al.*, 2001). However, a substantial span was observed between the shortest and the longest milk-

ing interval, it lasted from 600 to 840 minutes. Standard deviation for milking interval was on average 42 minutes (Klopčič *et al.*, 2001). There were no differences between the AM and PM milking and the composite sample in regard to milk fat, yet protein content was a bit lower in the morning milking. Fat and protein yield have higher variability compared to fat and protein content, the coefficient being between 31.3% and 38.5%. At recording fat content varied quite a lot (18.0% of the daily and 19.1% of the evening milking), while protein content did not vary to such an extent (12.0%).

For the statistical analysis as well as graphical presentation, the SAS/STAT package (SAS Institute Inc., 1996) was used. The following statistical analyses were used for the available data:

1. Phenotypic correlations between milk fat and milk protein yield, between the total, evening and morning milking and between the evening and morning milking were estimated.
2. Models for the evaluation of daily fat and protein content were developed. Regression coefficients for the correction of PM and AM fat and protein content in milk were estimated at separate milkings. Here, the same statistical models were used as for the assessment of daily milk yield (Klopčič *et al.*, 2001). Altogether 32 different models were examined where we used fat and protein content at PM or AM milking, milking interval, stage of lactation and parity as independent variables. In addition, the models contained also breed effects in order to check specific correction factor per breed. The most interesting models are presented

Table 1. Descriptive statistics for milk traits in experiment ($n = 4\ 070$)

Trait	Fat (%)		Fat (kg)		Protein (%)		Protein (kg)	
	\bar{x}	SD	\bar{x}	SD	\bar{x}	SD	\bar{x}	SD
Daily	4.18	0.71	0.78	0.28	3.41	0.41	0.64	0.20
PM	4.19	0.80	0.39	0.15	3.43	0.42	0.32	0.10
AM	4.19	0.76	0.39	0.14	3.40	0.41	0.32	0.10

\bar{x} = mean, SD = standard deviation, PM = evening milking, AM = morning milking

Table 2. Selected models

Model	df	Scalar notation
O	2	$y_i = \mu + b_1 m_i + e_i$
A	3	$y_i = \mu + b_1 m_i + b_2 t_i + e_i$
D	4	$y_i = \mu + b_1 m_i + b_2 t_i + b_3 d_i + e_i$
L	7	$y_i = \mu + b_1 m_i + b_2 t_i + b_7 (d_i/305) + b_8 (d_i/305)^2 + b_9 \ln(305/d_i) + b_{10} \ln^2(305/d_i) + e_i$
N	8	$y_i = \mu + b_1 m_i + b_2 t_i + b_4 m_i t_i + b_7 (d_i/305) + b_8 (d_i/305)^2 + b_9 \ln(305/d_i) + b_{10} \ln^2(305/d_i) + e_i$
YY	33	$y_i = \mu + P_i + b_{11} m_{ij} + b_{12} t_{ij} + b_{14} m_{ij} t_{ij} + b_{14} m_{ij}^2 + b_{15} l_{ij} + b_{16} l_{ij}^2 + b_{17} (d_i/305) + b_{18} (d_i/305)^2 + b_{19} \ln(305/d_i) + b_{10} \ln^2(305/d_i) + e_i$
Z	30	$y_{ij} = \mu + P_i + b_{11} m_{ij} + b_{12} t_{ij} + b_{14} m_{ij} t_{ij} + b_{15} l_{ij} + b_{16} l_{ij}^2 + b_{17} (d_i/305) + b_{18} (d_i/305)^2 + b_{19} \ln(305/d_i) + b_{10} \ln^2(305/d_i) + e_{ij}$
WXY	36	$y_{ij} = \mu + P_i + b_{11} m_{ij} + b_{12} t_{ij} + b_{13}^2 t_{ij} + b_{14} m_{ij} t_{ij} + b_{14} m_{ij}^2 + b_{15} l_{ij} + b_{16} l_{ij}^2 + b_{17} (d_i/305) + b_{18} (d_i/305)^2 + b_{19} \ln(305/d_i) + b_{10} \ln^2(305/d_i) + e_{ij}$

df = degrees of freedom, y = daily content, μ = intercept, m = AM or PM fat or protein content, b = regression coefficient, t = AM or PM milking interval in min, P = breed, d = days in milk, l = parity, e = residual

in Table 2. The same models were applied to fat and protein yield.

3. The criteria for model selection were coefficient of determination (R^2) and standard deviation for the residual (σ_e). Degrees of freedom (df) were a measure of model complexity.
4. Differences between statistical models were tested according to Mead (1970).
5. Suitability of models was studied in regard to bias, obtained by models O and A shown graphically in connection with fat and protein content.

RESULTS

Phenotypic correlations

Correlations between daily and PM/AM records were high for all traits (Table 3). Fat content was more variable than protein content, which was also expressed by lower correlations. In protein content, they were slightly higher for content than for yield. On the other hand, daily and PM/AM fat contents were correlated less than fat yields. The strongest correlation was estimated between daily and PM protein content ($r = 0.987$) while slightly lower correlations were computed for protein yield (from 0.899 for PM – AM to 0.970 for DPY – PM). The lowest correlations were observed between PM and AM records, especially for fat content ($r = 0.578$). Higher values were established between DFC and AM ($r = 0.832$) as well as between DFC and PM ($r = 0.888$).

In general, phenotypic correlations were high and comparable to published results. Correlations between daily and PM milkings were slightly higher in our study while others usually got higher values between daily and AM records. Nevertheless, correlations were high enough to encourage further investigations to apply the AT recording scheme in practice.

Comparison of models for fat and protein content and yield corrections using AT recording scheme

There were small differences between the tested models in regard to the coefficient of determination (Table 4) and mean square error. R^2 values for models with AM fat content ranged between

69.26% in model O, which includes only linear regression for fat content, and 73.73% in WXY model with Ali-Schaeffer lactation curve (Ali and Schaeffer, 1987), milk interval and parity, all within breed. The fit of the models for PM was commonly better compared to AM milking, explaining additionally around 8.5% of variability. The difference was higher for simple model O (9.6%) and for the most complex model WXY. As expected, mean square error for fat content was the highest in the simplest model O and the lowest in model WXY in both the PM and AM milking. The inclusion of milking interval (model A) additionally lowered σ_e and increased R^2 to 80.25% for PM and 71.61% for AM milking. Nevertheless, model A was simple enough and convenient for practical use. Stage of lactation described by higher-order polynomials or lactation curves did not increase R^2 or decrease σ_e substantially, neither did the effect of production technology, parity, milking method nor genotype. Minor improvements were obtained using models in which genotype was included. However, models including genotype were unverified, at least in this experiment, because all dairy breeds were not included. The group of crossbreds was too small for reliable estimates. Additionally, models with added genotype did not significantly differ from the others, therefore they were excluded from further investigations.

For fat yield R^2 values (Table 4) were higher than for fat content as expected because of the dependence between fat and milk yield. There was an increase by 10% in the PM and 13 to 17% in AM milking. Minimal differences of fat yield in the PM and AM milking (R^2) were noticed between simplest model O and model WXY, which included most effects and their interactions. In fat content, the maximum change, yet not significant, was observed between model O and A. Therefore, the model to consider should be chosen among the simple ones.

R^2 for protein content ranged from 95.48% in model A to 95.74% in model WXY for the AM milking (Table 4). These coefficients were a bit higher in the PM milking, ranging from 97.47% in model O to 97.65% in model WXY. The differences between models O and WXY were very small again, only 0.18% in the PM and 0.26% in the AM milking. There were no significant differences between the studied models. The values of R^2 for protein yield were slightly lower in all models compared to those for protein content. For protein

Table 3. Correlations for fat and protein between daily and PM/AM milking

Trait	Name	Fat (%)		Protein (%)			Fat (kg)			Protein kg		
		PM	AM	Daily	PM	AM	Daily	PM	AM	Daily	PM	AM
Fat Daily (%)	DFC	0.888	0.832	0.543	0.536	0.530	0.151	0.140	0.088	-0.178	-0.179	-0.173
Fat PM (%)	PM		0.578	0.482	0.483	0.466	0.138	0.231	0.01*	-0.157	-0.163	-0.144
Fat AM (%)	AM			0.503	0.497	0.496	0.107	0.03*	0.204	-0.141	-0.133	-0.148
Protein Daily (%)	DPC				0.987	0.977	-0.282	-0.263	-0.266	-0.226	-0.223	-0.215
Protein PM (%)	PM					0.952	-0.281	-0.267	-0.259	-0.226	-0.223	-0.215
Protein AM (%)	AM						-0.274	-0.250	-0.262	-0.220	-0.212	-0.196
Fat Daily (kg)	DFY							0.946	0.929	0.888	0.859	0.856
Fat PM (kg)	PM								0.810	0.841	0.861	0.784
Fat AM (kg)	AM									0.860	0.803	0.877
Protein Daily (kg)	DPY										0.970	0.965
Protein PM (kg)	PM											0.899

*not significant ($P > 0.05$), otherwise significant ($P < 0.0001$)

yield R^2 ranged within 2% for all models using AM as well as PM records. Differences between the studied models were significant neither for protein content nor for protein yield. Even the largest difference between models O and A was negligible.

Correction factors from selected statistical models

The correction factors for fat and protein (Table 5) content were presented for some of the selected models: the simplest model O, model A including milking interval and model D with linear regression for the stage of lactation. While the models did not differ significantly, we additionally tried to justify the fit of the model by estimating the bias along independent variables as shown in Figures 1 and 2.

The correction factors for fat content in model O, A and D were close to 0.8 for PM as well as AM milking. This means that the extreme measurements were less likely and therefore they should be regressed towards the average. The coefficients introduced some bias (Figure 1), however the mean square error was apparently reduced. This means that fat contents should be corrected. Correction for the longest milking interval lasting 4 hours brought as much as 0.5% of change in fat content. The change was meaningful even with shorter intervals and thus worth considering. The maximum increase due to the stage of lactation was 0.12% for records taken at 305 days in milk.

Liu *et al.* (2000) studied Holstein Friesian cows in Germany. Small mean square error and high correlation for fat and protein yield showed perfect goodness of fit of their model. In their case the correlation between the actual and estimated fat content was 0.943 for PM and 0.940 for AM fat yield, while it was 0.971 for PM and 0.966 for AM protein yield.

At the same time, the estimation of fat content in models O and A was compared with the actual measurements. The highest bias was observed for fat content (Figure 1), overestimating lower and underestimating higher values. Bias around the average was negligible. Minor differences were noticed between the models. Extreme values were biased more when AM records were used compared to PM. In fat

Table 4. Model comparison for fat and protein content and yield (coefficient of determination, %)

Model	df	Evening milking				Morning milking			
		fat (%)	protein (%)	fat (kg)	protein (kg)	fat (%)	protein (%)	fat (kg)	protein (kg)
O	2	78.83	97.47	89.54	94.05	69.26	95.48	86.23	93.10
A	3	80.25	97.53	89.68	95.50	71.61	95.54	86.31	94.46
D	4	80.57	97.56	90.19	95.62	71.73	95.58	86.90	94.58
L	7	80.70	97.56	90.20	95.62	72.25	95.65	87.02	94.60
N	8	80.72	97.56	90.21	95.69	72.27	95.65	87.03	94.70
YY	33	81.31	97.64	90.66	95.80	73.72	95.72	87.50	94.84
Z	30	81.13	97.63	90.53	95.80	73.62	95.72	87.39	94.83
WXY	36	81.35	97.65	90.67	95.81	73.73	95.74	87.51	94.86
Others									
from (G)	3	79.24	97.51	90.09	94.33	69.39	95.52	86.80	93.22
to (YY)	33	81.31	97.65	90.66	95.75	73.72	95.74	87.50	94.80

yield, bias was reasonably reduced especially in records with lower production. Estimated values were more severely underestimated whenever daily fat yield exceeded 2 kg, which happened in 1.7% of cases.

Correction factors for protein content (Table 5) were close to 1 suggesting that a measurement at AM or PM milking can sufficiently replace daily sample. Most of the coefficients varied around 0.97. Because AM or PM records described daily values well, additional independent variables like milking interval and stage of lactation were ex-

pected to be negligible. Consequently, regression coefficients for the interval between milkings were small, correcting the observed values by as much as 0.048% (Table 5) if the largest difference between AM and PM milking intervals occurred.

The bias for protein content was low. In other words, estimated values were in agreement with daily protein content (Figure 2). Small deviations can be noticed at very low protein values (< 2.6%) and at very high values (> 4.2%). Slightly higher bias was determined in protein yield, which is bound to the adequate milk yield.

Table 5. Parameter estimates with standard errors of estimates in models O, A, and D for fat and protein content

Model	Parameter	Fat (%)		Protein (%)	
		PM	AM	PM	AM
O	intercept	0.9071 ± 0.0271	0.9260 ± 0.0345	0.0730 ± 0.0085	0.1075 ± 0.0114
	partial content	0.7813 ± 0.0063	0.7756 ± 0.0081	0.9735 ± 0.0025	0.9731 ± 0.0033
A	intercept	-0.6582 ± 0.0953	-1.0461 ± 0.1125	-0.1050 ± 0.0198	-0.0723 ± 0.0263
	partial content	0.8009 ± 0.0062	0.7939 ± 0.0079	0.9745 ± 0.0024	0.9733 ± 0.0033
	interval	0.0021 ± 0.0001	0.0026 ± 0.0001	0.0002 ± 0.00002	0.0002 ± 0.00003
D	intercept	-0.6420 ± 0.0946	-1.0539 ± 0.1123	-0.0800 ± 0.0200	-0.0552 ± 0.0263
	partial content	0.7914 ± 0.0063	0.7865 ± 0.0080	0.9652 ± 0.0027	0.9632 ± 0.0037
	interval	0.0020 ± 0.0001	0.0026 ± 0.0001	0.0002 ± 0.00002	0.0003 ± 0.00003
	days in milk	0.0004 ± 0.00005	0.0002 ± 0.00006	0.00008 ± 0.00001	0.00008 ± 0.00001

*all parameter estimates were statistically significant ($P < 0.0001$)

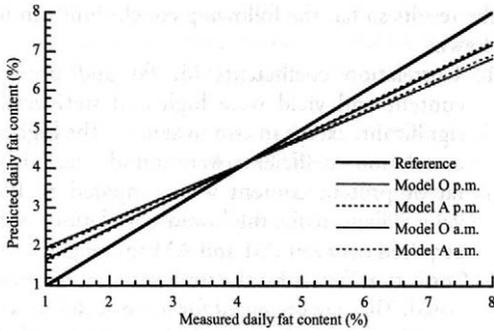


Figure 1. Bias for fat content in models O and A for evening (p.m.) and morning (a.m.) milking

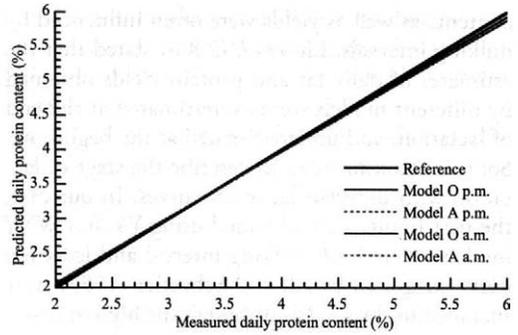


Figure 2. Bias for protein content in models O and A for evening (p.m.) and morning (a.m.) milking

DISCUSSION

The main objective of our study was to find an optimal statistical model for the estimation of correction factors which could be used for the prediction of daily fat and protein content, based on measurements taken from the PM and AM milking. Several models that included different environmental effects and their interactions were tested.

The most complex model WXY based on the PM milking (Table 2) estimated daily fat content with 90.2% accuracy and fat yield with 95.2% accuracy. Using model A for fat content, accuracy was reduced to 89.6% for PM and 84.6% for AM milking, while it was even higher for fat yield. Fat yield was estimated with 94.7% and 92.9% accuracy for PM and AM milking, respectively.

Protein content was estimated with higher accuracy. Model WXY estimated protein content with 98.8% and protein yield with 97.9% accuracy for PM milking (Table 4). The accuracy in model A, which included milking interval only, was not markedly reduced compared to model WXY. It was 98.7% for protein content and 97.7% for protein yield in the case of PM sampling. The estimates at PM milking were in general slightly better than at AM milking. The accuracy with AM milking was reduced to 97.7% for protein content and 97.2% for protein yield in model A.

Trappmann *et al.* (1998) reported that the difference between the estimated and actual daily fat yield depended on daily milk yield. In extreme values, the following bias of estimates occurred: in high daily milk yield the estimation based on partial

milking was underestimated and in low milk yield overestimated. This caused bias in individual animals as well as in herds where the average milk yield greatly differed from the average of the population.

In our case (Figure 1), fat content was overestimated for measurements below average for partial milking, and underestimated in fat content measurements above the average. Bias increased as the values deviated from the mean. A similar situation could be seen in fat yield if the values were below 0.8 kg or above 1.0 kg. There were no statistically significant differences between the particular models, considering fat yield. However, a different situation was observed for protein content. The estimated protein content from PM and AM milking was practically identical to the actual protein content in milk (Figure 2). Even with extreme values, bias was small and negligible. There were no statistical differences in protein content between the endmost models O and WXY. Protein yield was underestimated when protein content was above 0.8 kg (high milk yield and high protein content), and overestimated when there was less than 0.4 kg protein in milk. The studied models did not differ significantly. The largest improvement was obtained by replacing model O containing only partial milking with model A incorporating also milking interval. However, the difference was trivial. Several authors (Everett and Carter, 1968; Schaeffer and Rennie, 1976; DeLorenzo and Wiggans, 1986; Hargrove, 1994; Cassandro *et al.*, 1995; Rosati *et al.*, 1995; Averdunk *et al.*, 1998) found that the milking interval had a substantial effect on protein and fat measurements. Therefore, daily

contents as well as yields were often influenced by milking intervals. Liu *et al.* (2000) stated that the estimates of daily fat and protein yields obtained by different models were overestimated at the end of lactation, and underestimated at the beginning. So, it is recommended to describe the stage of lactation with different lactation curves. In our case, the best results were obtained using YY and WXY models where both milking interval and lactation curve suggested by Ali and Schaeffer (1987) were included in the model. Although the highest determination coefficient and the lowest mean square error were obtained, more complex models were not significantly better than the simplest ones.

The results proved that the AT recording scheme could be successfully applied in practice. However, the data were collected under experimental conditions. The number of herds and technicians as well as animals was limited. In addition, Brown breed was not included in the experiment. Prior to its application, it is highly recommended to collect additional data to test the correction factors on future records and data from other populations. Besides partial milking, it is necessary to account for milking interval as well. In current research, parity, stage of lactation, breed and seasonal effect on test day did not considerably improve the estimates. However, they might be analysed again as new data arises in order to estimate daily values more accurately.

Our study revealed that determination coefficients were high, and mean square errors were low in all models. Therefore the estimates for yield and content of fat and protein could be achieved with sufficient accuracy. No statistical differences were observed between the simplest model O with partial milking only, and the most complex model WXY including a number of effects and their interactions. It was established that the prediction of daily values could be performed with one of the simplest models studied. In particular circumstances whenever milking intervals before partial milkings differ much from each other, it might be safer to make adjustment also for milking interval as implemented in model A.

CONCLUSIONS

Different models to correct partial values were studied and compared for fat and protein content obtained by the AT recording scheme. Based on

the results so far, the following conclusions can be drawn:

1. Correlation coefficients for fat and protein content and yield were high and statistically significant, except in two instances. The highest correlation coefficients were found when daily fat or protein content was compared to PM values. Expectedly, the lowest correlations were acquired between PM and AM milking.
2. Correction factors for the studied traits were evaluated. They are presented for some of the chosen models: the simplest model O, model A including milking interval and model D additionally accounting for days in milk. The correction factors were statistically significant in these models.
3. Choosing a model with several parameters is neither necessary nor practical because the differences between the models are small and not statistically significant. Nevertheless, the chosen model has to contain at least partial values and milking interval.
4. Before making a final decision about the most appropriate model, bias in different cases and at extreme values of independent variables (milking interval, PM/AM, stage of lactation, parity) has to be examined on data from a wider scale of recorded population, gathered later on.
5. The combined studies on the prediction of daily milk yield, fat and protein content using AT recording scheme form a basis for the final decision making about changing the A4 method to AT recording in Slovenia. The cost of recording is also an important factor in this decision process.

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ABSTRAKT

Predikce denního obsahu tuku a bílkovin v mléce s použitím střídavého systému (AT) kontroly užítkovosti

Na dvanácti farmách ve Slovinsku byla sledována možnost zavedení systému AT kontroly užítkovosti místo v současnosti používané referenční metody A4. V průběhu běžné kontroly produkce byla zaznamenávána dojivost při večerním (PM) a ranním (AM) dojení. Byly stanoveny korelace mezi AM, PM a denními měřeními a testovány

rovnice pro hodnocení denních obsahů tuku a bílkovin v mléce. Všechny fenotypové korelace byly významné a dosahovaly hodnot od 0,578 (PM-AM) u obsahu tuku a 0,987 (DPC-PM) u obsahu bílkovin. Koefficient determinace (R^2) pro testované modely se pohyboval u obsahu tuku mezi 78,83 % až 81,35 % pro PM a 69,26 % až 73,73 % pro AM. U obsahu bílkovin bylo rozpětí hodnot R^2 97,47 % až 97,65 % pro PM a 95,48 % až 95,74 % pro AM. Rozdíly mezi modely byly malé a nevýznamné. Komplexní modely však snižovaly zkreslení u extrémních hodnot.

Klíčová slova: skot; střídavý (AM – PM) systém kontroly užítkovosti; obsah tuku; obsah bílkovin

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Growth, feed efficiency and carcass characteristics of Czech Pied and Holstein bulls

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ABSTRACT: Live weight gain, feed intake, feed conversion efficiency, slaughter characteristics and carcass composition were compared in 12 Czech Pied (C) and 10 Holstein (H) bulls. The average initial weight and age of animals were 263 kg and 258 days, respectively. The target slaughter live weight was 550 kg. No significant differences between the groups were found in daily live weight gains. Average daily dry matter intakes were lower in C for the first 146 days of the test period and for the whole test period by 9 and 7%, respectively. The bulls of the C group gained more efficiently in the first 146 days of the test period and in the whole test period by 11% ($P < 0.05$) and 7% ($P = 0.0550$), respectively. Dressing percentage and visually scored carcass conformation were higher ($P < 0.001$) for C. The H bulls had lower proportions of total meat ($P < 0.001$), grade I meat ($P < 0.05$) and grade II meat ($P < 0.05$), whereas C had a lower bone proportion in the carcass ($P < 0.001$). Internal fat production and separable carcass fat proportion were higher for H ($P < 0.05$). It is concluded that the lower feed costs, higher dressing percentage and more favourable carcass characteristics observed in the Czech Pied bulls will result in considerably more efficient beef production in comparison with the Holstein bulls.

Keywords: Czech Pied cattle; Holstein cattle; bulls; growth; feed intake; carcass composition

In spite of growing numbers of beef cattle, dairy and dual-purpose breeds are still the main source of beef in the Czech Republic. A major part of beef comes from Holstein and Czech Pied breeds (Kvapilík *et al.*, 2002). While Holstein cattle is a specialised dairy breed with its breeding programme aimed exclusively at milk yield and some functional traits, for Czech Pied cattle beef production is also of great importance. Differences in carcass value were further stressed when the new grading system was introduced in 2002 (CSN 46 6120, 2000).

The modern history of Black and White cattle in the Czech Republic started in the 1960's. Its breed structure has recently been shifting towards a higher genetic proportion of Holstein cattle which improved milk production but had a negative impact on carcass characteristics (Urban *et al.*, 1997).

Carcass quality of Holstein bulls at the average slaughter weight of 366 and 432 kg was analysed by Chládek *et al.* (1998) and Chládek and Ingr

(2001). The effects of feeding level and slaughter weight in Holstein bulls were also investigated by Keane and Fallon (2001).

The effect of live weight at slaughter in Czech Pied bulls was evaluated by Vrchlabský *et al.* (1988). Based on their results the authors recommend the optimum slaughter weight of bulls ranging from 550 to 650 kg.

In the past considerable research was conducted on growth, carcass and meat quality differences between Czech Pied and Black and White bulls (Župka *et al.*, 1985; Teslík *et al.*, 1995, 1996; Bartoň *et al.*, 1996a,b). Similar traits were investigated in German Fleckvieh and German Holstein bulls slaughtered at birth and at 6, 12, 18 and 24 months of age (Szücs *et al.*, 2001a,b). Much less information is available on economically important traits like feed intake and conversion or results of carcass classification according to the new grading system.

Relative carcass values of Simmental and Holstein breeds and their crosses determined in veal calves, fattening bulls and culled cows were evaluated by Kaufmann *et al.* (1996). The study demonstrated the reduced carcass values with the increasing Holstein gene percentage.

The objective of the present study was to evaluate current differences in feed intake and efficiency, growth and carcass composition of the two most common cattle breeds in the Czech Republic.

MATERIAL AND METHODS

Totally 24 bulls were used in the experiment, 12 of the Holstein (H) and 12 of the Czech Pied (C) breed. They were the progeny of 7 Holstein and 10 Czech Pied sires. Throughout the whole fattening period, the animals were loose-housed in two boxes (12 animals per box). Each box was equipped with three feeding troughs with electronically controlled gates (Insentec, Marknesse, NL) for daily recording of individual feed intakes. The initial weight of bulls entering the experiment was determined using the average weight from two consecutive days and averaged 263 kg. The bulls were weighed once a month. The target slaughter live weight was 550 kg. During the fattening period, two H bulls were removed from the experiment due to health problems. The data were collected for the period from start to 146 days of the experiment (when first animals were slaughtered) and for the whole experiment from start to slaughter.

Throughout the experiment, the animals were offered a mixed diet consisting of maize and alfalfa silage, alfalfa hay and concentrates (rolled barley and soybean meal, 24% on a dry matter basis) *ad libitum*. The diet was calculated with the software "Operative Management of Cattle Nutrition 5.5" (AgroKonzulta, Žamberk, CZ) and covered all the dietary requirements of bulls for the expected daily gain of 1.2 kg. The diet analysis was: dry matter (DM) 549 g/kg, crude protein (CP) 134 g/kg DM, protein digestible in small intestine (PDI-N) 83 g/kg DM, net energy (NEV) 6.81 MJ/kg DM.

The bulls were slaughtered in the experimental abattoir of the Research Institute of Animal Production. After slaughter, hot carcass weights and weights of internal fats (kidney, rumen and intestinal) were recorded. Dressing percentage was calculated as the proportion of hot carcass weight from slaughter weight, carcass gain was obtained

as the ratio of hot carcass weight and days of age at slaughter. The carcasses were classified for conformation and fatness according to the beef carcass classification system (CSN 46 6120, 2000) that is equivalent to the EU classification system.

After a 24-hour chill period, cold carcass weights were recorded and the right sides were divided into primal joints (CSN 57 0277, 2002). The joints were separated into lean meat, bones and tendons and separable fat and their weights were recorded. The total meat yield was calculated as the total lean meat from individual joints plus lean trimmings. The grade I meat was determined as the total weight of lean meat from rump, shoulder, sirloin and fillet and the grade II meat as the lean meat from the other joints plus lean trimmings. *Musculus longissimus lumborum et thoracis* (MLLT) area was measured at the section between the 8th and 9th thoracic vertebrae.

Statistical analyses were performed using the GLM procedure of SAS (SAS Institute Inc., 2001) with the individual animal as an experimental unit. The model included breed as the fixed effect (Model 1). Age at the start of the test was included as a covariate when analysing feed intake and efficiency characteristics (Model 2).

Model 1

$$Y_{ij} = \mu + A_i + e_{ij}$$

where: Y_{ij} = observed variable

μ = overall mean

A_i = fixed effect of breed ($i = 1, 2$)

e_{ij} = random error

Model 2

$$Y_{ij} = \mu + A_i + b(x - \bar{x}) + e_{ij}$$

where: Y_{ij} = observed variable

μ = overall mean

A_i = fixed effect of breed ($i = 1, 2$)

$b(x - \bar{x})$ = linear regression on age at the start of the test

e_{ij} = random error

RESULTS AND DISCUSSION

Growth characteristics of bulls are given in Table 1. The average initial weight and age of bulls were 263 kg and 258 days, respectively. The animals were slaughtered at the average weight of 551 kg.

Table 1. Growth characteristics of bulls

	Breed		SE	Significance
	C	H		
Initial weight (kg)	265.5	260.9	10.44	NS
Weight at 146 days of test (kg)	472.9	466.1	12.16	NS
Slaughter weight (kg)	547.2	554.3	5.79	NS
Initial age (d)	276.4	239.2	8.95	NS
Age at slaughter (d)	508.9	477.0	8.59	NS
Total days of test (d)	234.5	239.4	7.51	NS
Daily gain from 0 to 146 days of test (kg/d)	1.417	1.398	0.036	NS
Daily gain in whole test (kg/d)	1.209	1.227	0.026	NS
Daily gain from birth to slaughter (kg/d)	1.015	1.091	5.793	NS

NS = not significant

The average growth rate in the first 146 days of test (1 408 kg/d) tended to be higher than that for the whole test (1 218 kg/d). The differences in live weights and live weight gains between the breeds were not significant. Similar live weight gains in Black and White and Czech Pied bulls slaughtered in different slaughter weights were also reported by Teslík *et al.* (1995) and Bartoň *et al.* (1996a,b). On the other hand, higher live weight gains in Czech Pied in comparison with Black and White bulls were found by Ptáček and Suchánek (1985).

Feed and energy intakes per day and per 1 kg of live weight gain adjusted to the same age at start of the test are shown in Table 2. Average daily feed intakes are higher for the whole test period than for the period of the first 146 days (8 316 and 8 774 kg DM/d, respectively). As for feed conversion efficiency, the bulls tended to gain more efficiently in the first test period in comparison with the whole test period (5 948 and 7 265 kg DM/kg live weight gain, respectively) due to increasing maintenance requirements.

Dry matter intakes from start to 149 days of test and from start to slaughter were higher for H bulls by 9% ($P = 0.0614$) and 7% ($P = 0.0967$), respectively. Feed conversion efficiency was more favourable for C bulls in the first 149 days of test ($P < 0.05$) and throughout the experiment ($P = 0.0550$). As the animals were offered the same mixed diet throughout the experiment, similar tendencies were found for energy, crude protein and PDI-N intakes and conversion efficiency. No

data concerning the differences in feed intake and efficiency between Holstein and Czech Pied breeds are available to compare directly with the above-mentioned results. Significantly lower daily dry matter and ME intakes of Friesian cattle in comparison with Limousin × Friesian and Belgian Blue × Friesian crossbreds were reported by Steen (1995). Southgate *et al.* (1988) concluded that purebred British Friesian and Canadian Holstein steers had a lower efficiency of live weight gain than beef breed crosses when slaughtered at the same external fat cover. The trend towards a higher silage intake per kg live weight for Friesian steers than for the beef crosses was also observed by Keane and More O'Ferrall (1992).

The main effects of breed on slaughter traits are given in Table 3. Dressing percentage was significantly higher for C bulls ($P < 0.001$). In spite of that, no significant difference was found for carcass gain due to better growth performance of H animals prior to the start of the test. The difference in dressing percentage of 2.4% between C and H groups observed in the present study is somewhat lower than the difference between German Fleckvieh and German Holstein bulls slaughtered at 18 months of age reported by Szücs *et al.* (2001a) but in this case the slaughter weight of Fleckvieh animals was markedly higher. The differences in dressing percentage between Czech Pied and Black and White bulls slaughtered at the average slaughter weights of 530, 575 and 620 kg ranged from 1.6 to 2.6% (Teslík *et al.*, 1995; Bartoň *et al.*, 1996a,b). The in-

Table 2. Feed and energy intake and efficiency

	Breed		SE	Significance
	C	H		
DM intake from start to 146 days of test (kg/d)	7.916	8.716	1.189	NS
Energy (NEV) intake from start to 146 days of test (MJ/d)	53.9	59.4	8.10	NS
CP intake from start to 146 days of test (kg/d)	1.060	1.168	0.159	NS
PDI-N intake from start to 146 days of test (kg/d)	0.657	0.723	0.099	NS
DM intake from start to slaughter (kg/d)	8.465	9.082	1.043	NS
Energy (NEV) intake from start to slaughter (MJ/d)	57.6	61.8	7.10	NS
CP intake from start to slaughter (kg/d)	1.134	1.217	0.140	NS
PDI-N intake from start to slaughter (kg/d)	0.702	0.754	0.086	NS
DM intake from start to 146 days of test (kg DM/kg live-weight gain)	5.606	6.290	0.773	*
Energy (NEV) intake from start to 146 days of test (MJ/kg live-weight gain)	38.2	42.8	5.27	*
CP intake from start to 146 days of test (kg CP/kg live weight gain)	0.751	0.842	0.103	*
PDI-N intake from start to 146 days of test (kg PDI-N/kg live weight gain)	0.465	0.522	0.064	*
DM intake from start to slaughter (kg DM/kg live-weight gain)	7.003	7.527	0.757	NS
Energy (NEV) intake from start to slaughter (MJ/kg live-weight gain)	47.7	51.3	5.16	NS
CP intake from start to slaughter (kg CP/kg live weight gain)	0.939	1.009	0.102	NS
PDI-N intake from start to slaughter (kg PDI-N/kg live weight gain)	0.581	0.625	0.063	NS

* $P < 0.05$, NS = not significant

ternal fat proportion of slaughter weight was higher in H bulls ($P < 0.05$).

Visually assessed conformation was significantly better ($P < 0.001$) for the C group than for the H group. The difference of nearly 1 point on a 6-point scale can be considered as very high and economically important. Fatness score tended to be higher for H bulls but the difference was not significant.

Table 4 shows carcass composition of bulls. Different tissue weights (meat, separable fat, bones

and tendons) are given as percentages of side weight. Carcass composition was considerably affected by breed with most traits significantly superior for C animals. Carcasses of C bulls had a higher percentage of total meat ($P < 0.001$), grade I meat from high-value joints ($P < 0.05$) and grade II meat ($P < 0.05$). These results are confirmed by a larger ($P < 0.01$) area of MLLT relative to slaughter weight. The percentage of bones and tendons was higher in carcasses of H bulls and it resulted in the significantly lower value ($P < 0.001$) of meat:bone

Table 3. Slaughter characteristics

	Breed		SE	Significance
	C	H		
Carcass weight (kg)	313.7	304.3	4.11	NS
Dressing percentage (%)	57.29	54.88	0.242	***
Carcass gain (kg/d)	0.622	0.639	0.013	NS
Carcass conformation ¹	3.75	4.70	0.100	***
Carcass fatness ²	2.83	3.10	0.140	NS
Internal fat (% slaughter weight)	2.79	3.67	0.172	*

* $P < 0.05$, *** $P < 0.001$, NS = not significant

¹Scale 1 = S (best) to 6 = P (poorest)

²Scale 1 (leanest) to 5 (fattest)

Table 4. Carcass composition

	Breed		SE	Significance
	C	H		
Total meat (% side)	79.03	76.61	0.251	***
Grade I meat (% side)	39.45	38.01	0.306	*
Grade II meat (% side)	39.58	38.59	0.206	*
Separable fat (% side)	1.81	2.31	0.090	*
Bones and tendons (% side)	18.19	20.04	0.208	***
Meat:bones and tendons	4.358	3.834	0.059	***
Grade I:grade II meat	0.998	0.986	0.011	NS
LLT area/100 kg slaughter weight (cm ²)	16.26	14.18	0.275	**

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$, NS = not significant

ratio. H bulls had a higher percentage of separable fat ($P < 0.05$), which is consistent with their previously mentioned higher production of internal fat and higher carcass fatness score and indicates greater overall fatness of H animals slaughtered at the constant slaughter weight.

The results of carcass composition are widely in agreement with the findings of Szücs *et al.* (2001a), who compared German Fleckvieh and German Hostein bulls. Kaufmann *et al.* (1996) observed a tendency towards reduced carcass values with the increasing Holstein Friesian gene percentage when evaluating Simmental and Holstein Friesian cattle and their crosses. The difference in total meat percentage between the C and H groups (2.42%)

is higher than the differences between Czech Pied and Black and White bulls slaughtered at the average slaughter weights of 530, 575 and 620 (from 0.98 to 1.89%) reported by Teslík *et al.* (1995) and Bartoň *et al.* (1996a,b). Together with the other traits of carcass composition it may indicate a reduced carcass quality connected with the gradual change in the structure of the Black and White cattle population towards a higher proportion of Holstein strain.

The present results show that Holstein and Czech Pied bulls had similar growth rates but the Holsteins tended to gain less efficiently. As expected, C bulls had higher dressing percentages and their carcasses were more favourably scored for conformation and

fatness. Great superiorities of C animals were observed in carcass composition traits. It is concluded that the above-mentioned differences in favour of the Czech Pied bulls will result in considerably more efficient beef production in comparison with the Holstein bulls.

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ABSTRAKT

Růst, spotřeba krmiva, konverze živin a složení jatečného těla býků plemen české strakaté a holštýnské

Denní přírůstky, spotřeba krmiva, konverze živin, ukazatele jatečného rozboru a složení jatečného těla byly porovnávány u 12 býků plemene českého strakatého (C) a 10 býků plemene holštýnského (H). Průměrná počáteční hmotnost byla 263 kg, kterou býci dosáhli v průměrném věku 258 dnů. Cílová porážková hmotnost byla 550 kg. V přírůstcích živé hmotnosti nebyly mezi skupinami zjištěny významné rozdíly. Denní příjem sušiny a energie do 146 dnů testu byl u skupiny C o asi 9 % nižší než u skupiny H ($P = 0,0614$). Za celé období výkrmu pak tento rozdíl činil asi 7 %. Průměrná konverze krmiva a energie na 1 kg přírůstku v počátečních 146 dnech testu byla o 11 % ($P < 0,05$) příznivější u skupiny C, za celý výkrm se jednalo o rozdíl 7 % ($P = 0,0550$). Hodnoty dosažené jatečné výtěžnosti byly 57,3 % u C a 54,9 % u H ($P < 0,001$). Vizualně hodnocená zmasilost jatečných těl byla téměř o 1 stupeň (šestibodová stupnice) příznivější u skupiny C. Jatečná těla býků H obsahovala o 2,4 % nižší podíl masa celkem ($P < 0,001$), z toho o 1,4 % méně masa I. jakosti ($P < 0,05$) a o 1,0 % méně masa II. jakosti ($P < 0,05$). Naopak podíl kostí a šlach byl u této skupiny o 1,8 % ($P < 0,001$) vyšší. Vyšší tendence k ukládání tuku při konstantní porážkové hmotnosti u skupiny H je zřejmá z podílu tuku ukládaného v tělních dutinách, podílu tuku oddělitelného při bourání jatečného těla a z vizuální klasifikace do tříd protučnělosti. Nižší náklady na spotřebovaná krmiva, vyšší jatečná výtěžnost a lepší ukazatele složení jatečného těla vyjádřené příznivějším zařazením do tříd jakosti u býků českého strakatého jsou jednoznačným předpokladem pro vyšší ekonomickou efektivitu výkrmu těchto zvířat v porovnání s výkrmem býků holštýnského plemene.

Klíčová slova: český strakatý skot; holštýnský skot; býci; růst; spotřeba krmiv; složení jatečného těla

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Influence of the nutrition level on fattening and carcass characteristics of Awassi ram lambs

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ABSTRACT: The objective of the study was to evaluate the effect of nutrition level on fattening and carcass characteristics of Awassi ram lambs in Jordan. Thirty-six newly weaned Awassi ram lambs of similar weights were randomly allocated to three groups (control group = 12, experimental group I = 12 and experimental group II = 12). Animals were fed 3 diets (nutrition levels) for a period of 61 days. These experimental diets were isocaloric and isonitrogenous. The control group received the traditional feed used for fattening Awassi ram lambs in Jordan (barley, soybean and wheat bran). By-products group (experimental group II) received a ration containing tomato pomace, olive pulp and dried poultry litter while the other treatment (experimental group I) received the vitamin supplement Vitamix[®] OSZ added to the traditional ration fed in Jordan. Six animals from each group were slaughtered at the end of the experiment for carcass evaluation. The results show that total weight gain (WG) and average daily gain (DWG) of ram lambs during the study were 17.87 ± 0.43 kg and 292 ± 0.01 g in experimental group I, 17.43 ± 0.43 kg and 286 ± 0.01 g in control group and 15.07 ± 0.43 kg and 246 ± 0.01 g in experimental group II, respectively. Differences between the individual groups as depending on the nutrition level were highly significant ($P \leq 0.01$). The best feed conversion and the lowest cost of 1 kg weight gain 5.19 ± 0.17 and 0.632 ± 0.02 Jordanian Dinar (JD) were achieved in ram lambs of experimental group I, 5.32 ± 0.17 and 0.660 ± 0.02 JD in ram lambs of control group and 6.15 ± 0.17 and 0.738 ± 0.02 JD when compared with feed conversion in ram lambs of experimental group II, the difference between the groups was highly significant ($P \leq 0.01$). The results of the present study document that the concentrate mixture with Vitamix[®] OSZ has positive effects on fattening performance of ram lambs. The ram lambs had better feed conversion and lower cost of 1 kg meat gain when the concentrate mixture with Vitamix[®] OSZ was used. The results of the study also show that by-products could replace traditional feed in ruminant diets but it need not always be economical. Awassi ram lambs could be fattened to high weights but a considerable amount of fat would be produced.

Keywords: sheep; Awassi; ram lambs; fattening performance; carcass value; mineral; vitamin

The level of expenditure associated with feeding depends on the employed production system: the percentage of total production costs approaches the figure of around 70% that is characteristic of developed countries (Charray *et al.*, 1992).

A lot of lamb meat producers in many developing countries use mainly barley and soybean meal for lamb fattening. Nevertheless, high prices of soya and more often its inaccessibility on the mar-

ket constrain the farmers towards the use of new sources of feed.

Many authors published and confirmed the effect of nutrition level on fattening performance and carcass value of lambs: Alwash *et al.* (1983), Yacoub *et al.* (1987), Al Jassim *et al.* (1991), Momani Shaker *et al.* (1995) and others.

The methods how to improve yield performances, cost reduction and application of a profitable sys-

tem of lamb rearing and fattening were studied by Yacoub *et al.* 1987; Harb, 1994; Momani Shaker *et al.*, 1995, 2002; Kuchčík *et al.*, 1996.

According to the authors the most important indicator, besides the direct influence on effective fattening, is the average daily gain that is in positive correlation with indicators of meat quality.

Horák (1999) concluded that the high growth ability of lambs could not be achieved without concentrate feed. Further he recommended to use intensive feeding with an *ad libitum* regime.

A lot of authors describe the *ad libitum* fattening system of lambs as the best method, especially for meat production (Jones and Forbes, 1982; Hassan *et al.*, 1983; Yacoub and Kashmoula, 1988; Al Jassim *et al.*, 1991; Momani Shaker *et al.*, 1997).

Momani Shaker *et al.* (1997) mentioned the fact of higher dressing percentage in the time of higher slaughter weight of lambs.

Many authors concluded that from the slaughter aspect, the most important indicator is the weight

of leg that is about two thirds of prime meat in joints. At the same time the leg is an indicator of wholesale carcass meatiness (Slaná, 1987; Momani Shaker *et al.*, 1997).

The objective of the study was to evaluate the effect of nutrition level on fattening and carcass characteristics of Awassi ram lambs in Jordan.

MATERIAL AND METHOD

The study was carried out on ram lambs of Awassi sheep breed kept in the Agriculture Centre for Research and Production at Jordan University of Science and Technology, Irbid. The campus is located at 36° north and 590 m above sea level. The average rain precipitation is about 220–230 mm per year.

Thirty-six newly weaned Awassi ram lambs of similar weights were randomly allocated to three groups (control group = 12, experimental

Table 1. Ingredients and nutrient content of diets used for ram lamb fattening

Ingredients of diets	Diet in percentage		
	control	group I	group II
Barley grains	49	49	23
Soybean meal	10	10	6.5
Wheat bran	15	15	7.2
Alfalfa	14.9	14.4	8.0
Wheat straw	10	10	–
Olive oil cake (pulp and kernels)	–	–	25
Sunflower oil	–	–	2.5
Tomato pomace	–	–	13.3
Dried poultry litter	–	–	13.3
DCP	0.5	0.5	–
Mineral supplements	0.1	–	–
Salt	0.5	0.5	0.32
Vitamix® OSZ (from the Czech Republic)	–	0.6	–
Vitamin supplements	–	–	0.08
Limestone	–	–	0.80
Analysed nutrient content			
Dry matter (g)	887.1	903.4	916.6
Crude protein (g)	164.4	159.8	159.0
Ether extract (g)	23.9	25.1	22.4
Crude Fibre (g)	160.3	155.5	118.7
Ash (g)	63.3	65.3	51.5
ME (MJ/kg)	10.92	10.89	11.03

group I = 12 and experimental group II = 12) in a completely randomised design, each treatment having 3 replications. Animals were fed *ad libitum* 3 different diets for 61 days. These different diets (Table 1) were isocaloric and isonitrogenous. The control group (Con) received the traditional feed used for fattening Awassi ram lambs in Jordan (barley grain, soybean and wheat bran). Experimental group I received the vitamin supplement Vitamix® OSZ (Table 2) added to the traditional ration fed in Jordan (VX) while the experimental group II received a ration containing by-products (BP) such as tomato pomace, olive oil cake and dried poultry litter.

The feed was administered gradually daily at 8:00 a.m. and 4:00 p.m. the lambs were fed on a group basis.

The lambs were vaccinated against enterotoxaemia and drenched and sprayed to protect against internal and external parasites.

At the beginning of the study, the average live weight of ram lambs in control group was 23.07 ± 1.20 kg, experimental group I 23.17 ± 1.20 kg and experimental group II 22.83 ± 1.20 kg. The study started after 10-day adaptation of lambs to assess concentrate mixtures.

Live weight of ram lambs was recorded once weekly, daily was recorded feed offered and refused in all groups. The refusal was kept at around 10% of the feed offered. Water was available all the time from dish drinkers.

At the end of the study, the average live weight of ram lambs in control group was 40.50 ± 0.48 kg, experimental group I 41.00 ± 0.48 kg and experimental group II 37.90 ± 0.48 kg.

Six ram lambs from each group were chosen for control slaughter at the end of the experiment for carcass evaluation. The choice followed the range $\pm 1 \sigma$ (standard deviation) with respect to the average live weight of each group.

The ram lambs were slaughtered after 18-hour fasting. After slaughter the weight of lungs with heart and liver, full and empty digestive tract, testicles and skin was recorded.

Carcasses were weighed and chilled for 20 hours at 5°C, weighed again and some carcass dimensions were measured: body length, leg length, shoulder width and carcasses were weighed.

Carcasses were cut into standardized wholesale cuts (Kadim *et al.*, 1989):

1. Leg – hind limbs separated from the back between the 5th and the 6th lumbar vertebra.
2. Loin – back proportion including the 13th thoracic vertebra and 1st to 5th lumbar vertebra.
3. Rack – back proportion including the 7th and the 12th thoracic vertebra.
4. Shoulder – fore trunk carcass proportion including neck, middle neck and fore shank separated between the 6th and the 7th thoracic vertebra.

All carcass cuts were weighed, recorded and these parameters were also measured:

- fat thickness on loin between the 12th and 13th thoracic vertebra at 110 mm from the backbone,
- *musculus longissimus dorsi* (MLD) was determined planimetrically between the 12th and 13th thoracic vertebra
- length and width of MLD area
- fat thickness over the MLD area
- fat thickness with meat on loin between the 12th and 13th thoracic vertebra at a point 110 mm from the mid-line
- fat thickness over loin between the 12th and 13th ribs at a point 110 mm from the mid-line (mm)
- fat thickness over the ventral edge of *m. gluteus medius*
- fat thickness over shoulder between the 7th and 8th pectoral vertebra at a point 110 mm from the mid-line

The obtained data were processed by a mathematico-statistical program (SAS) according to

Table 2. Content of effective substances in 1 kg of Vitamix® OSZ

	Macro-elements				Micro-elements						Vitamins			
	Ca	P	Ca : P	Na	Mg	Zn	Co	Se	Mn	J	Fe	A	D3	E
	(g/kg)	(g/kg)		(g/kg)	(g/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(I.U./kg × 1 000)	(mg/kg)	(mg/kg)
Vitamix® OSZ	155	65	2.3 : 1	55	25	2 860	20	10	1 135	60	690	450	55	500

Vitamin and mineral premix for group II is commonly used for sheep in Jordan

the model equation with fixed effect by the least-squares method.

Model

$$Y_i = \mu + D_i + e_i$$

where: Y_i = live weight of Awassi ram lamb

μ = overall mean

D_i = effect of the I -th diets (i = Con, VX and Bp)

e_i = residue

RESULTS AND DISCUSSION

In feeding sheep, particularly young lambs, attention will possibly be paid to mineral supplements that influence total nutritive value of feed ration, animal health, performance and consumption of fed ration per unit performance.

The main characteristics of fattening performance and carcass value of ram lambs as depending on the nutrition level are presented in Tables 3 to 8.

The results related to fattening performance traits of all Awassi ram lambs ($n = 36$) included in this study are shown in Table 3. The results show that the differences in final live weight of ram lambs between the individual groups as depending on the nutrition level were highly significant ($P \leq 0.01$). The final live weight of ram lambs was 41.00 ± 0.48 kg in experimental group I, 40.50 ± 0.48 kg in control group and 37.90 ± 0.48 kg in experimental group II. The results also show that total weight gain (WG) and average daily gain (DWG) of ram lambs during the study were 17.87 ± 0.43 kg and 292 ± 0.01 g in experimental group I, 17.43 ± 0.43 kg and 286 ± 0.01 g in control group and 15.07 ± 0.43 kg and 246 ± 0.01 g in experimental group II, respectively. Differences between

Table 3. Fattening performance traits of all ram lambs included in this study

	Control group $n = 12$	Group I $n = 12$	Group II $n = 12$	F-value
Initial live weight (LW)(kg)	23.07 ± 1.20	23.17 ± 1.20	22.83 ± 1.20	2.03
Final live weight (kg)	40.50 ± 0.48^c	41.00 ± 0.48^c	37.90 ± 0.48^{ab}	11.87***
Total weight gain (WG) (kg)	17.43 ± 0.43^c	17.87 ± 0.43^c	15.07 ± 0.43^{ab}	12.17***
Average daily weight gain (DWG) (g)	286 ± 0.01^c	292 ± 0.01^c	246 ± 0.01^{ab}	12.84***
Feed intake per head/day (kg)	1.71 ± 0.01	1.68 ± 0.01	1.65 ± 0.01	2.54
Dry matter intake per head/day (kg)	1.52 ± 0.01	1.52 ± 0.01	1.51 ± 0.01	0.04
Feed conversion (kg DM intake/kg weight gain)	5.32 ± 0.17^c	5.19 ± 0.17^c	6.15 ± 0.17^{ab}	8.42***
Feed conversion (kg)	6.00 ± 0.19^c	5.74 ± 0.19^c	6.71 ± 0.19^{ab}	6.49**
Cost of 1 kg weight gain (JD)	0.660 ± 0.02^c	0.632 ± 0.02^c	0.738 ± 0.02^{ab}	6.42**

* $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$

Table 4. Fattening performance traits of ram lambs

	Control group $n = 6$	Group I $n = 6$	Group II $n = 6$	F-value
Initial live weight (LW) (kg)	23.23 ± 2.100	21.92 ± 2.100	25.42 ± 1.00	0.71
Final live weight (kg)	39.50 ± 2.48	39.58 ± 2.48	40.50 ± 2.48	0.05
Total weight gain (WG) (kg)	16.27 ± 0.86	17.67 ± 0.86	15.08 ± 0.86	2.23
Average daily weight gain (DWG) (g)	0.266 ± 0.01	0.290 ± 0.01	0.247 ± 0.01	2.23
Live weight after fasting (kg)	36.97 ± 2.31	37.17 ± 2.31	38.30 ± 2.31	0.10

the individual groups as depending on the nutrition level were highly significant ($P \leq 0.01$). These results were in accordance with those reported by Al Jassim *et al.* (1991), but lower results were obtained on Karadi lambs by Yacoub and Kashmoula (1988).

Table 3 shows that the best feed conversion (kg DM intake/kg weight gain) was 5.19 ± 0.17 in ram lambs of experimental group I, 5.32 ± 0.17 in ram lambs of control group and 6.15 ± 0.17 in ram lambs of experimental group II, the difference between the groups was highly significant ($P \leq 0.01$). Our results of feed conversion obtained in this study are worse than those found by Al Jassim *et al.* (1991) in his study on Awassi male lambs, but they are better than the results found by Yacoub and Kashmoula (1988) on Karadi male lambs. However, similar results were reported by Momani Shaker *et al.* (2002) on different genotypes. Harb

(1994) found the feed conversion of Awassi male lambs to be 6.55 in an experiment lasting for 154 days with high concentrate rations.

Another important criterion that influences the economy of fattening is cost of 1 kg weight gain. Table 2 shows that the lowest cost of 1 kg weight gain 0.632 ± 0.02 Jordanian Dinar (JD) was achieved in ram lambs of experimental group I, 0.660 ± 0.02 JD in ram lambs of control group and 0.738 ± 0.02 JD in ram lambs of experimental group II, the difference between the groups was also highly significant ($P \leq 0.01$). Similar results were reported by Momani Shaker *et al.* (2002) on different genotypes.

The results of fattening performance traits of male lambs chosen ($n = 18$) for control slaughter are presented in Table 4. Average daily weight gain and total weight gain during the experiment were 0.290 ± 0.01 and 17.87 ± 0.43 kg in experimen-

Table 5. Average weights of by-products of slaughtered ram lambs

	Control group $n = 6$	Group I $n = 6$	Group II $n = 6$	F-value
Weight of skin (kg)	4.42 ± 0.27	4.05 ± 0.27	4.12 ± 0.27	0.52
Weight of full digestive tract (kg)	3.85 ± 0.27	3.56 ± 0.27	4.07 ± 0.27	0.88
Weight of empty digestive tract (kg)	1.13 ± 0.06	1.07 ± 0.06	1.14 ± 0.06	0.37
Weight of small intestine (kg)	0.82 ± 0.04^b	0.69 ± 0.04^{ac}	0.86 ± 0.04^b	5.44*
Weight of large intestine (kg)	0.85 ± 0.06	0.78 ± 0.06	0.90 ± 0.06	0.77
Weight of heart (kg)	0.150 ± 0.01	0.148 ± 0.01	0.158 ± 0.01	0.57
Weight of spleen (kg)	0.063 ± 0.005	0.070 ± 0.005	0.072 ± 0.005	0.67
Weight of liver (kg)	0.615 ± 0.05	0.528 ± 0.05	0.600 ± 0.05	0.81
Weight of lungs (kg)	0.478 ± 0.04	0.495 ± 0.04	0.545 ± 0.04	0.92
Weight of intestinal fat (kg)	0.398 ± 0.09	0.510 ± 0.09	0.378 ± 0.09	0.59
Weight of testicles (kg)	0.191 ± 0.03	0.183 ± 0.03	0.192 ± 0.03	0.03
Weight of kidney (kg)	0.103 ± 0.01	0.108 ± 0.01	0.108 ± 0.01	0.17
Weight of kidney fat (kg)	0.193 ± 0.04	0.225 ± 0.04	0.125 ± 0.04	1.61

* $P \leq 0.05$

Table 6. Average measurements of hanging carcass

	Control $n = 6$	Group I $n = 6$	Group II $n = 6$	F-value
Body length (cm)	103 ± 1.82	102 ± 1.82	102 ± 1.82	0.05
Leg length (cm)	19.8 ± 0.67	19.1 ± 0.67	20.5 ± 0.67	1.10
Shoulder width (cm)	15.6 ± 0.50	16.8 ± 0.50	15.93 ± 0.50	1.53

tal group I, 0.266 ± 0.01 g and 16.27 ± 0.86 kg in control group and 0.247 ± 0.01 g and 15.08 ± 0.86 kg in experimental group II, respectively. No differences between the individual groups as depending on the nutrition level were found.

The results of by-product weights of slaughtered ram lambs are presented in Table 5. Evaluation of carcass by-products shows that the nutrition level affected the weight of small intestine ($P \leq 0.01$). The nutrition level did not affect the other indicators of by-products.

When evaluating the hanging carcass measurements (Table 6) in dependence on the nutrition level, no statistically significant differences between the groups were found.

The weight and proportions of carcass cuts are of great importance for mutton production. The average weights and proportions of carcass wholesale cuts including and excluding tail fat are shown in Table 7.

The highest dressing percentage (including tail fat) in cold condition was $52.43 \pm 1.00\%$ in ram lambs of experimental group I, and when compared with ram lambs of control group $51.06 \pm 1.00\%$ and ram lambs of experimental group II $50.13 \pm 1.00\%$ no statistically significant difference was found. Our results are similar to the results ob-

tained by Alwash *et al.* (1983), Harb (1994) and Momani Shaker *et al.* (2002). The results reported by Yacoub and Kashmoula (1988) were also in the range of values from 48.87 to 49.22% for fat tailed Awassi and Karadi lambs breeds. Momani Shaker *et al.* (1997) also reported that in the control slaughter of eight pure Charollais ram lambs the average slaughter weight was 42.1 kg, average carcass weight in warm condition was 21.96 kg and average dressing percentage 52.45.

The evaluation of dressing percentage of carcass without tail fat as depending on the nutrition level proved statistically significant differences ($P \leq 0.001$).

The highest dressing percentage of carcass without tail fat was $46.02 \pm 0.69\%$ in carcasses of experimental group I, and when compared with carcasses of experimental group II $43.72 \pm 0.69\%$ and carcasses of control group $43.49 \pm 0.69\%$ statistically significant differences were found ($P \leq 0.05$). Similar results were reported by Momani Shaker *et al.* (2002) on Awassi ram lambs.

When evaluating the percentage proportions of individual cuts of lamb carcass, no statistically significant differences were observed between the groups as depending on the nutrition level in leg percentage, loin percentage and rack percentage

Table 7. Average weights and proportions of carcass wholesale cuts including and excluding tail fat

	Control <i>n</i> = 6	Group I <i>n</i> = 6	Group II <i>n</i> = 6	<i>F</i> -value
Carcass weight in cold condition (kg)	18.98 ± 1.46	19.55 ± 1.46	19.30 ± 1.46	0.04
Dressing percentage in cold condition (%)	51.06 ± 1.00	52.43 ± 1.00	50.13 ± 1.00	1.34
Tail fat weight (kg)	2.85 ± 0.35	2.43 ± 0.35	2.50 ± 0.35	0.41
Carcass weight without tail fat (kg)	16.13 ± 1.18	17.13 ± 1.18	16.80 ± 1.18	0.19
Leg weight (kg)	5.54 ± 0.38	6.10 ± 0.38	5.95 ± 0.38	0.59
Loin weight (kg)	1.77 ± 0.16	1.70 ± 0.16	1.78 ± 0.16	0.08
Rack weight (kg)	1.68 ± 0.14	1.78 ± 0.14	1.64 ± 0.14	0.27
Shoulder weight (kg)	6.63 ± 0.47	6.96 ± 0.47	6.81 ± 0.47	0.13
Tail fat percentage (%)	14.67 ± 1.19	12.23 ± 1.19	12.72 ± 1.19	1.17
Percentage carcass weight without tail (%)	43.49 ± 0.69^b	46.02 ± 0.69^{ac}	43.72 ± 0.69^b	4.06*
Leg percentage (%)	29.37 ± 0.63	31.34 ± 0.63	31.01 ± 0.63	2.82
Loin percentage (%)	9.27 ± 0.46	8.72 ± 0.46	9.31 ± 0.46	0.53
Rack percentage (%)	8.80 ± 0.22	9.08 ± 0.22	8.52 ± 0.22	1.56
Shoulder percentage (%)	35.17 ± 0.72	35.74 ± 0.72	35.32 ± 0.72	0.16

* $P \leq 0.05$

Table 8. Average measurements of separable fat in carcass

	Control <i>n</i> = 6	Group I <i>n</i> = 6	Group II <i>n</i> = 6	<i>F</i> -value
MLD area (cm ²)	10.76 ± 0.86	11.75 ± 0.86	12.92 ± 0.86	1.60
Width of MLD area (mm)	53.83 ± 2.35	55.58 ± 2.35	56.42 ± 2.35	0.31
Length of MLD area (mm)	26.91 ± 1.35	27.00 ± 1.35	30.08 ± 1.35	1.79
Fat thickness over MLD area (mm)	4.33 ± 0.56	3.67 ± 0.56	3.83 ± 0.56	0.38
Fat thickness with meat over loin between 12th and 13th ribs at a point 110 mm from the mid-line (mm)	16.92 ± 1.40	17.25 ± 1.40	14.67 ± 1.40	1.01
Fat thickness over loin between 12th and 13th ribs at a point 110 mm from the mid-line (mm)	10.75 ± 1.49	10.83 ± 1.49	7.58 ± 1.49	1.57
Fat thickness over the ventral edge of <i>m. gluteus medius</i> (mm)	12.50 ± 1.56	12.50 ± 1.56	12.92 ± 1.56	0.03
Fat thickness over shoulder between 7th and 8th pectoral vertebra at a point 110 mm from the mid-line (mm)	5.67 ± 1.24	6.00 ± 1.24	6.17 ± 1.24	0.05

that represent the prime meat and shoulder percentage.

The results of measurements of separable fat in carcass cuts are presented in Table 8. The MLD area and fat thickness over MLD muscle displayed no statistically significant differences between the groups. The average fat thickness over MLD obtained in this study was 3.67 ± 0.56 mm in carcasses of experimental group I, 3.83 ± 0.56 mm in carcasses of experimental group II and 4.33 ± 0.56 mm in carcasses of control group. However, the differences between individual groups were not significant. Similar results were reported by Yacoub and Kashmoula (1988) in Karadi male lambs. But Bayindir (1980) suggested that fat thickness over MLD was significantly and positively correlated with slaughter weight, and it increased as slaughter weight increased.

The results of the present study document that a concentrate mixture with Vitamix® OSZ has positive effects on fattening performance of ram lambs. The ram lambs have better feed conversion and lower cost of 1 kg meat gain when a concentrate mixture with Vitamix is used.

The results of the study also show that by-products can replace traditional feed in ruminant diets if by-products can be bought economically.

Awassi ram lambs could be fattened to high weights but a considerable amount of fat would be produced.

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ABSTRAKT

Vliv úrovně výživy na výkrmovou schopnost a jatečnou hodnotu beránků plemene awassi

Cílem práce bylo sledovat a vyhodnotit vliv úrovně výživy na výkrmovou schopnost a jatečnou hodnotu beránků plemene awassi v Jordánsku. Do výkrmového pokusu bylo vybráno 36 beránků pocházejících z jedináčků, kteří byli rozděleni do třech skupin (kontrolní a dvě pokusné skupiny) po 12 zvířatech. V kontrolní skupině měli beránci při zahájení pokusu průměrnou živou hmotnost $23,07 \pm 1,20$ kg, v 1. pokusné skupině $23,17 \pm 1,20$ kg a ve 2. pokusné skupině $22,83 \pm 1,20$ kg. Pokus byl zahájen po desetidenním přípravném období beránků. Beránci v kontrolní skupině byli krmeni krmnou směsí používanou v Jordánsku (ječný šrot, sojový extrahovaný šrot a pšeničné otruby). V 1. pokusné skupině byli beránci krmeni stejnou krmnou směsí jako v kontrolní skupině doplněnou přípravkem Vitamix® OSZ dovezeným z České republiky. Beránci ve 2. pokusné skupině byli krmeni krmnou směsí obsahující rajčatové zbytky, slunečnicový olej a drůbeží podestýlku. Na konci pokusu, který trval 61 dnů, byla průměrná živá hmotnost beránků v kontrolní skupině $40,50 \pm 0,48$ kg, v 1. pokusné skupině $41,00 \pm 0,48$ kg a ve 2. pokusné skupině $37,90 \pm 0,48$ kg. Z každé skupiny bylo vybráno šest beránků ke kontrolní porážce. Výběr byl proveden v rozsahu $\pm 1 \sigma$ (směrodatné odchytky) od průměrné živé hmotnosti každé skupiny. Získané údaje byly zpracovány matematicko-statistickým programem SAS podle modelové rovnice s pevným efektem metodou nejmenších čtverců. Celkový přírůstek a průměrný denní přírůstek čistokrevných beránků plemene awassi během pokusu byly v kontrolní skupině $17,43 \pm 0,43$ kg, resp. $286 \pm 0,01$ g; v 1. pokusné skupině $17,87 \pm 0,43$ kg, resp. $292 \pm 0,01$ g a ve 2. pokusné skupině $15,07 \pm 0,43$ kg, resp. $246 \pm 0,01$ g; zjištěné rozdíly mezi skupinami byly významné ($P \leq 0,05$). Statisticky významný rozdíl ($P \leq 0,05$) byl zjištěn u konverze krmiv, která byla v 1. pokusné skupině $5,74 \pm 0,19$, v kontrolní skupině $6,00 \pm 0,19$ a ve 2. pokusné skupině $6,71 \pm 0,19$. Průměrná jatečná výtěžnost u beránků v kontrolní skupině byla $51,06 \pm 1,00$ %, v 1. pokusné skupině $52,43 \pm 1,00$ % a ve 2. pokusné skupině $50,13 \pm 1,00$ %; zjištěné rozdíly nebyly statisticky významné. Při hodnocení podílů jednotlivých částí jatečného trupu beránků nebyly zjištěny významné rozdíly u procentických podílů kýty, hrudníku a ramene v závislosti na úrovni výživy. Nejnižší podíl kýty $29,37 \pm 0,63$ % byl u jatečných trupů kontrolní skupiny a nejvyšší $31,34 \pm 0,63$ % u jatečných trupů 1. pokusné skupiny. Při hodnocení šířky a délky plochy MLD, výšky tuku nad plochou MLD, tloušťky masa s tukem na ledvině mezi 12. a 13. hrudním obratlem ve vzdálenosti 110 mm od páteře, výšky tuku na kýtě za 6. bederním

obratlem a výška tuku mezi 7. a 8. hrudním obratlem též ve vzdálenosti 110 mm od páteře nebyl zjištěn průkazný rozdíl v závislosti na úrovni výživy. Z výsledků spotřeby krmiv je patrné příznivé působení doplňku Vitamix® OSZ na výkrmnost beránek. U směsi, ve které byl Vitamix® OSZ použit, bylo dosaženo vyšší využitelnosti krmiv a tím i lepší konverze krmiv. Při zkrmování směsi, která obsahovala testovaný Vitamix® OSZ, byl dosažen vyšší denní přírůstek. Z hodnocení užitečnosti beránek v závislosti na úrovni výživy je zřejmé, že požadavky na množství a spotřebu krmiv se s věkem beránek zvyšují.

Klíčová slova: ovce; beránci; plemeno awassi; výkrmnost; jatečná hodnota, minerální látky; vitaminy

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Meat quality and beef production parameters of Holstein steers fattened up to 10–12 months of age

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ABSTRACT: An experimental group of 26 Holstein steers was fattened and slaughtered at 10–12 months of age with the aim to analyse feedlot performance parameters and carcass value and their mutual relationships. The animals were castrated using a non-invasive Burdizzo tongs method by 4 months of age. Total mean values were as follows: age at slaughter 331.0 days, live weight at slaughter 368.1 kg, total weight gain 246.5 kg, duration of fattening 214.5 days, daily weight gain 1.150 kg, net weight gain 0.610 kg, dressing percentage 52.0%, carcass weight 191.5 kg, weight and proportion of kidney fat 5.16 kg and 2.70%, weight and proportion of fat trim 3.71 kg and 3.92%, dry matter content in muscle 25.3%, fat content in muscle 2.00%, collagen content in muscle 0.825%, pH_{24} 5.50, drip loss 1.66% and remission on cut (525 nm) 7.80%. Live weight at slaughter, total weight gain and daily weight gain significantly affected carcass traits – carcass weight, net daily gain and proportion of fat trim. Meat quality (most of all drip loss, dry matter content in muscle and pH_{24}) was also affected by feedlot performance parameters.

Keywords: Holstein cattle; steers; beef production; carcass; meat quality

Fattening of steers for beef production is rather rare in the Czech Republic therefore it has not been subjected to research to a large extent.

Tyleček (1957) analysed the effect of age of Czech Pied bulls at castration on their feedlot performance. He found daily weight gain 881 g in early castrated (at 35 days of age) animals and 952 g in late castrated animals (at 437 days of age); the weight and proportion of kidney fat 7.5 kg and 1.84% compare to 6.72 kg and 1.51% and live weight at slaughter 460.75 kg compares to 498.75 kg in the two respective groups. As for the meat quality of the early and late castrated animals, proportion of fat in muscle was 1.72% and 1.13%, respectively and dry matter in muscle 26.12% and 25.30%, respectively in the two observed groups.

Braun and Lizal (1970) studied the fattening of loose housed steers and presented these results: age at slaughter 565.2 days, live weight at slaughter 360.2 kg, weight of kidney fat 3.8 kg, dressing

percentage 56.2%, fat content in muscle 2.21% with dry matter 26.05%.

A major part of recent research in this field was carried out by Chládek and Ingr (2003), who analysed feedlot performance and meat quality of Holstein steers fattened up to 400–500 kg. Some of the results of analyses were as follows: weight at slaughter 435.8 kg, age at slaughter 417.5 days, daily weight gain 1 089 kg, net weight gain 0.566 kg, dressing percentage 51.4%, weight and proportion of kidney fat 5.05 kg and 2.27%, weight and proportion of fat trim 3.93 kg and 3.52%, dry matter and fat content in muscle 25.0% and 1.92%, collagen content in muscle 1.16%, pH_{24} 5.51, drip loss 1.07% and remission (525 nm) 7.76%. The authors concluded that carcass traits were most of all affected by live weight and age at slaughter and total weight gain; the effect of daily weight gain and duration of fattening was less significant. Meat quality was affected by duration of fattening and

more significantly by live weight and age at slaughter. Meat quality was most significantly affected by total weight gain while daily weight gain had no effect at all.

Feedlot performance of steers was studied abroad for example by Waldman *et al.* (1968). They analysed data on steers fattened up to 342.0 kg or 459.0 kg of live weight slaughtered at the age of 344.4 days and 459.6 days, respectively, with daily weight gain 0.88 and 0.93 kg, respectively.

Papstein and Grosse (1986) observed feedlot performance of German Black and White bulls castrated at 2, 7 and 12 months of age using an invasive and non-invasive method of castration. They came to a conclusion that the proportion of kidney fat was considerably higher in steers castrated at 2 months of age than in animals castrated at later age. A non-invasive method of castration gave more favourable results.

Lower dressing percentage of steers was likely to be caused by a higher proportion of kidney fat; for example in the experiment of Baber *et al.* (1984) dressing percentage was as low as 52.19% and in Bruckmaier *et al.* (1997) it dropped even to 50.6%.

Gerhardy (1995) studied the quality of beef produced in fattening systems typical of Northern Germany. Apart from the other cattle categories, he analysed data on 8 steers slaughtered at 32.3 months of age with carcass weight 343.6 kg and net weight gain 350 g. In *musculus longissimus dorsi* (MLD) he found: fat content 5.56%, collagen content 1.95% and water content 72.07%.

Keane (1994) observed 40 Friesian bulls castrated at the age of 147 days. He found out the following values: age at slaughter 750 days, weight at slaughter 597 kg, dressing percentage 52.6%, carcass weight 314.3 kg, weight of kidney and diaphragm fat 16.2 kg, intramuscular fat 11.9% and subcutaneous fat 9.6%. MLD of the analysed animals contained 72.8% of water, 22.5% of protein, 3.8% of fat and 1.1% of ash.

Parrassin *et al.* (1999) carried out an experiment in a group of 83 bulls, part of which were castrated at 7 months of age and 265 kg of live weight and the rest was castrated at 16 months of age and 458 kg of live weight. According to their results, age at castration had only a small effect on carcass weight and carcass traits. Thirteen Holstein bulls castrated at 7 months were slaughtered at 812 days of age and 709 kg of live weight; their mean carcass weight was 374 kg and dressing percentage 52.8%.

Musculus longissimus lumborum et thoracis (MLLT) had pH 5.56 and it contained 4.75% of fat and 5.25 mg/g of total collagen.

The accession of the Czech Republic to EU will probably bring about increased interest in fattening of steers, especially young animals up to 12 months of age. Thus the aim of this study was to evaluate main parameters of meat quality and quantity and their mutual relationships in young Holstein steers fattened up to 10–12 months of age.

MATERIAL AND METHODS

Data on 26 Holstein steers slaughtered at 10–12 months of age were analysed. The animals were castrated using a non-invasive Burdizzo tongs method by 4 months of age. The diet consisted of ad lib crushed barley and wheat, limited amount of protein concentrate (which contained a required quantity of vitamins and minerals) and limited amount of alfalfa hay. The daily ration was calculated to ensure 1.3 kg of daily gain, as recommended by Sommer *et al.* (1994).

The following parameters were evaluated on the day of slaughter: live weight and age, total gain, duration of fattening, daily gain, net gain, carcass weight, dressing percentage, weight and proportion of kidney fat. More parameters were measured (only in the right half of carcass) 24 hours after slaughter: weight and proportion of fat trim, percentage of dry matter, fat and collagen in MLLT (a sample between 8th and 9th pectoral vertebrae), remission on cut (525 nm) and drip loss. Measured values were analysed for statistical parameters: mean (\bar{x}), standard deviation (s_x), coefficient of variation ($V\%$) and correlation (r).

RESULTS

Parameters of the feedlot performance of experimental Holstein steers are presented in Table 1. The mean live weight at slaughter was 368.1 kg at the age of 331.0 days. The duration of fattening was 214.5 days with the total weight gain 246.5 kg, which gave the daily weight gain 1.150 kg. The coefficient of variation was highest in total weight gain (12.27%) and lowest in duration of fattening (4.29%). Carcass traits are presented in Table 2. The mean carcass weight was 191.5 kg, which gave dressing percentage 52.0% and net daily gain

Table 1. Some parameters of feedlot performance of Holstein steers ($n = 26$)

Feedlot performance parameters	\bar{x}	$s_{\bar{x}}$	V (%)
Live weight at slaughter (kg)	368.1	39.97	10.86
Age at slaughter (day)	331.0	15.94	4.82
Total weight gain (kg)	246.5	30.25	12.27
Duration of fattening (day)	214.5	9.21	4.29
Daily weight gain (kg)	1.150	0.140	12.17

Table 2. Some carcass traits of Holstein steers ($n = 26$)

Carcass traits	\bar{x}	$s_{\bar{x}}$	V (%)
Carcass weight (kg)	191.5	21.05	10.99
Dressing percentage (%)	52.0	1.24	2.38
Net daily gain (kg)	0.610	0.078	12.79
Weight of kidney fat (kg)	5.16	1.551	30.06
Proportion of kidney fat (%)	2.70	0.803	29.74
Weight of fat trim ¹ (kg)	3.71	0.953	26.68
Proportion of fat trim ¹ (%)	3.92	1.082	27.60

¹from the right half of carcass

Table 3. Some meat quality parameters of Holstein steers ($n = 26$)

Meat quality parameters	\bar{x}	$s_{\bar{x}}$	V (%)
Dry matter content in muscle (%)	25.3	0.632	2.49
Fat content in muscle (%)	2.00	0.910	45.50
Collagen content in muscle (%)	0.825	0.384	46.54
Drip loss (48 h p.m.) (%)	1.66	0.637	39.37
pH ₂₄	5.50	0.085	1.54
Remission on cut (24 h p.m.) (%)	7.80	2.21	28.33

0.610 kg. The weight of kidney fat was 5.16 kg (2.70%) and the fat trim from the right half of carcass 3.71 kg (3.92%). The highest variability was found in weight of kidney fat (30.06%) and lowest in dressing percentage (2.38%). Meat quality parameters are shown in Table 3. The content of dry matter in muscle was 25.3%, the proportion of fat in muscle 2.00% and collagen 0.825%. The drip loss was 1.66%, pH₂₄ 5.50 and remission on cut 7.80%. The highest variability (46.54%) was found in collagen content in muscle and lowest (1.54%) in pH₂₄.

The coefficients of correlation between the parameters of feedlot performance and carcass traits are presented in Table 4. Highly significant correlations ($P < 0.01$) were found between carcass weight and live weight at slaughter ($r = 0.978$), total weight gain ($r = 0.928$) and daily weight gain ($r = 0.890$) and also between net daily gain and live weight at slaughter ($r = 0.875$), total weight gain ($r = 0.873$) and daily weight gain ($r = 0.964$). There were significant correlations between proportion of fat trim and daily weight gain ($r = -0.491$, $P < 0.01$), total weight gain ($r = -0.387$, $P < 0.05$) and live weight

Table 4. Coefficients of correlation between parameters of feedlot performance and carcass traits ($n = 26$)

Carcass traits	Parameters of feedlot performance				
	live weight at slaughter	age at slaughter	total weight gain	duration of fattening	daily weight gain
Carcass weight	0.978**	0.207	0.928**	0.092	0.890**
Dressing percentage	0.043	0.259	-0.024	-0.230	0.057
Net daily gain	0.875**	0.204	0.873**	-0.242	0.964**
Weight of kidney fat	0.223	-0.142	0.201	-0.106	0.232
Proportion of kidney fat	-0.136	-0.240	-0.143	-0.148	-0.097
Weight of fat trim ¹	0.047	0.049	-0.043	0.204	-0.123
Proportion of fat trim ¹	-0.327*	-0.071	-0.387*	0.274	-0.491**

¹from the right half of carcass

* $P < 0.05$; ** $P < 0.01$

Table 5. Coefficients of correlation between parameters of feedlot performance and meat quality parameters ($n = 26$)

Meat quality parameters	Parameters of feedlot performance				
	live weight at slaughter	age at slaughter	total weight gain	duration of fattening	daily weight gain
Dry matter content in muscle	-0.301*	-0.280	-0.351*	-0.452**	-0.192
Fat content in muscle	-0.249	0.045	-0.336*	-0.158	-0.288
Collagen content in muscle	0.203	-0.021	0.289	0.410**	0.149
Drip loss (48 h p. m.)	-0.411**	0.243	-0.477**	-0.152	-0.492**
pH ₂₄	0.082	0.305*	0.207	0.618**	-0.001
Remission on cut (24 h. p. m.)	-0.278	-0.148	-0.336*	-0.467**	-0.167

* $P < 0.05$; ** $P < 0.01$

at slaughter ($r = -0.327$, $P < 0.05$). No correlations were found between age at slaughter or duration of fattening and all of the observed carcass traits.

Coefficients of correlation between feedlot performance and meat quality parameters are presented in Table 5. Highly significant correlations ($P < 0.01$) were found between drip loss and daily weight gain ($r = -0.492$), total weight gain ($r = -0.477$) or live weight at slaughter ($r = -0.411$). Coefficients of correlation between duration of fattening and dry matter content in muscle ($r = -0.452$), collagen content in muscle ($r = 0.410$), remission on cut ($r = -0.467$) and pH₂₄ ($r = 0.618$) were also highly significant ($P < 0.01$). Coefficients of correlation between total weight gain and dry matter content in muscle ($r = -0.351$), fat content in muscle ($r = -0.336$) and remission on cut ($r =$

-0.336) were significant ($P < 0.05$). Significant coefficients of correlation ($P < 0.05$) were also found between dry matter content in muscle and live weight at slaughter ($r = -0.301$) and between age at slaughter and pH₂₄ ($r = 0.305$).

DISCUSSION

Our feedlot performance parameters were quite favourable; e.g. the daily weight gain and net weight gain were higher than those presented by Tyleček (1957) or Waldman *et al.* (1968) and even higher than the highest values found by Chládek and Ingr (2003). This was probably due to the applied system of feeding and nutrition and the method of castration; Papstein and Gross (1986) also obtained

better results in non-surgically castrated animals compared to surgical methods of castration.

Our values of weight at slaughter were comparable to those presented by Waldman *et al.* (1968) or Braun and Lízal (1970); the rest of the quoted authors studied meat production and quality of older animals slaughtered at higher weight.

The high daily weight gain did not reflect in higher weight and proportion of the observed fat tissue. Both Tyleček (1957) and Keane (1994) presented higher values of kidney fat weight. Our dressing percentage was lower than the values presented by Tyleček (1957) and comparable to the values of Baber *et al.* (1984) and Parrassin *et al.* (1999). Bruckmaier *et al.* (1997) found the dressing percentage by 1.5% lower than our value.

Our meat quality parameters corresponded with results of Chládek and Ingr (2003); while dry matter and fat content in muscle, pH₂₄ and remission were almost identical, our drip loss value was somewhat higher and collagen content in muscle lower. Our fat and dry matter values in MLD were comparable with the results of Tyleček (1957) and Braun and Lízal (1970). Higher values of fat content in MLD were reported by Keane (1994), Parrassin *et al.* (1999) and Gerhardy (1995); however, age and weight of their experimental animals were higher. A higher fat content in MLD was likely to be responsible for higher values of dry matter in muscle presented in all three studies. Collagen content in muscle was lower than the values found by Gerhardy (1995) and considerably lower than the values of Parrassin *et al.* (1999). Again, a lower age and weight of our animals were probably responsible for the differences.

The relationships between feedlot performance parameters and carcass traits or meat quality parameters can be compared to the results of Chládek and Ingr (2003); however, they observed steers with higher live weight and age. We found a less significant negative effect of age at slaughter and duration of fattening on net daily gain that corresponded with a less significant effect of feedlot performance parameters on fat content in muscle. Feedlot performance parameters had a rather negative effect on the proportion of fat trim.

The age at slaughter and the duration of fattening were positively correlated to pH₂₄; the drip loss was higher and its correlation with feedlot performance parameters was more significant in our study (in contrast with the above-mentioned authors who observed older animals). These facts could suggest a hypothesis

that steers of a certain age (as in our study) could be more sensitive to negative external effects.

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ABSTRAKT

Masná užitkovost a jakost masa holštýnských volků vykrmovaných do věku 10 až 12 měsíců

Byl analyzován soubor 26 kusů holštýnských volků poražených ve věku od 10 do 12 měsíců s cílem kvantifikovat základní ukazatele masné užitkovosti a kvality masa včetně jejich vzájemného vztahu. Všechna zvířata byla kastrována nekrvavou metodou Burdizzo kleštěmi nejpozději ve věku čtyř měsíců. U celého souboru byly zjištěny tyto průměrné hodnoty: věk a živá hmotnost při porážce 331,0 dnů a 368,1 kg, celkový přírůstek živé hmotnosti a délka výkrmu 246,5 kg a 214,5 dnů, denní přírůstek živé hmotnosti a netto přírůstek 1.150 kg a 0,610 kg, jatečná výtěžnost a hmotnost jatečně opracovaného těla 52,0 % a 191,5 kg, hmotnost a podíl ledvinového loje 5,16 kg a 2,70 %, hmotnost a podíl lojem tvořeného ořezu 3,71 kg a 3,92 %, obsah sušiny a tuku ve svalovině 25,3 % a 2,00 %, obsah kolagenních bílkovin ve svalovině 0,825 %, pH_{24} 5,50, ztráta masné šťávy samovolným odkapem 1,66 % a remise (při 525 nm) 7,80 %. Ze sledovaných ukazatelů výkrmnosti byl zjištěn průkazný vliv jen živé hmotnosti při porážce, celkového přírůstku živé hmotnosti a denního přírůstku živé hmotnosti, a to pouze na hmotnost jatečně opracovaného těla, netto přírůstek a podíl lojem tvořeného ořezu. U jakosti masa byly sledovanými ukazateli výkrmnosti nejvíce ovlivněny ztráty masné šťávy samovolným odkapem, obsah sušiny ve svalovině a pH_{24} .

Klíčová slova: holštýnský skot; volci; masná užitkovost; kvalita masa

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Determination of metals in cow's milk by flame atomic absorption spectrophotometry

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ABSTRACT: The essential (Ca, Cu, Fe, Mg, Mn, Zn) and toxic metals (Pb and Cd) were determined by flame atomic absorption spectrophotometry (FA-AAS) in raw cow's milk. Milk was sampled four times in March 2000 on fifteen farms near Križ in the Zagreb region from bulk milk directly into plastic bottles (to avoid contamination). The raw cow's milk samples were digested in an MLS-1200 Mega Microwave Digestion System with MDR Technology, and the metals were determined directly by FA-AAS in the solutions of digested samples. Statistical analyses were performed using statistical software SAS v. 8.0. Contents of essential minerals (Ca, Cu, Fe, Mg, Mn, Zn) in milk from Croatian farms are on the normal levels in comparison with the data from other countries. The level of toxic metals (Pb and Cd) was lower than the tolerance level defined by Croatian regulations (Pb < 100 µg/l and Cd < 10 µg/l).

Keywords: lead; cadmium; copper; iron; manganese; magnesium; calcium; raw cow's milk; flame atomic absorption spectrophotometry

Increased awareness of the influence of diets on human health has prompted producers to produce food of higher quality, rich in nutrients and nutraceuticals, in environmentally friendly manner. On the other hand, raw materials for food production are getting poor in essential minerals and vitamins at the same time.

Milk and dairy products have been recognized all over the world for a long time as good for their sensory properties, but also for their beneficial influence on human health (Steijns, 2001). On the other hand, milk is an expensive raw material produced by animals (Boland *et al.*, 2001). To produce milk or to make its products of good quality and to reduce their price, a good raw material is needed. Therefore constant control of raw milk bought from farms is necessary. Milk should be controlled not only for fat and proteins as it is usual, but also for mineral content whenever possible.

Milk is known as an excellent source of Ca, and it can supply moderate amounts of Mg, smaller amounts of Zn and very small amounts of Fe and Cu (Levy *et al.*, 1985; Pennington *et al.*, 1987,

1995a,b). Therefore the essential metals are interesting for determination of their adequate daily intake by the organism. On the other hand, due to the growing environmental pollution it is also necessary to determine and monitor the levels of toxic metals in milk, such as lead and cadmium, because they can significantly influence the human and animal health (Steijns, 2001).

The most frequently used technique to determine metals in food and biological materials is atomic absorption spectrophotometry (AAS). If the concentrations of metals are high enough, AAS determinations are usually done by flame atomic absorption spectrophotometry (FA-AAS). When the concentrations of metals are low, electrothermal atomic absorption spectrophotometry (EA-AAS) is applied. Both techniques should give the same results if the concentration of metals is above the detection limit of FA-AAS (Jorhem, 1993).

Because of low industrial production Croatia has a unique opportunity to produce milk rich in nutritional elements and with very low levels of toxic substances at the same time. In order to determine

the quality of raw material bought by the Croatian dairy industry one-month research was conducted on 15 family farms in the region of Ivanič grad, the region of biggest milk producers in Croatia. Our attention was focused on the mineral composition of milk.

MATERIAL AND METHODS

Sampling strategy. Samples of raw cow's milk were collected four times in March 2000 from fifteen farms located near Križ in the Zagreb region. The cows on each farm were fed dry hay and mineral premixes and drank water from the pump. Raw milk was sampled from the bulk milk of the farms directly into carefully washed plastic bottles because of the relatively great possibility of sample contamination, especially by lead and cadmium.

Precautions against contamination. All chemicals were of the highest available purity. Deionised water was used. The laboratory ware was cleaned with chromosulphuric acid and rinsed with deionised water. The laboratory ware was dipped in 10% HNO₃ for 24 h, rinsed with deionised water, dipped in 3% EDTA solution for 24 h and rinsed with deionised water again.

Analytical procedure. The fat and protein content (%) was determined on Bently 150 Infrared milk analyser.

To determine the concentrations of metals chemicals of the highest available purity were used. HNO₃ (Riedel) was used for the dilution and mineralization of raw milk samples, H₂O₂ (9.791 mol/dm³, Riedel) was used for digestion of all milk samples. Lead nitrate (3.019 × 10⁻³ mol/dm³, Merck) and cadmium nitrate (4.230 × 10⁻³ mol/dm³, Merck) solutions were used as calibration standards. All solutions were prepared with deionised water.

The metals (calcium, copper, iron, magnesium, manganese, zinc, lead and cadmium) were analysed by FA-AAS in a total of 60 milk samples. To eliminate the organic part of milk, 0.500 g of raw cow's milk was treated with 6 ml of 65% HNO₃ and 1 ml 30% H₂O₂, mixed and digested in an MLS-1200 Mega Microwave Digestion System with MDR Technology. Lead and cadmium were determined with ammonium salts pyrrolidine-1-dithiocarboxylic acid (APDC) into methyl-isobutyl ketone by FA-AAS. The other investigated metals were determined directly by FA-AAS.

Instrumentation. PU 9100X FA-AAS equipped with Epson FX-850 printer was used. The instrument was controlled by Philips P 3120 PC. The air/acetylene flame was used for the analysis of metals. Instrumental conditions for the determinations of metals in raw cow's milk are given in Table 1.

Statistics. Data were analysed by General Linear Models procedure. Mean differences were separated by Duncan's Multiple Range Test. The level of significance was set at $P < 0.05$. All analyses were performed using statistical software SAS v. 8.0.

RESULTS

Average mineral concentration of raw cow's milk is shown in Figure 1. The results of ANOVA are summarized in Table 2. Significant correlations between the investigated parameters are shown in Figure 2.

Fat and protein

In the period of investigations fat content in raw cow's milk from 15 different farms was significantly different, ranging from 2.55 to 4.62%. Similar results were obtained for protein content that ranged from 2.81 to 4.1%. The correlation between fat and protein content was not statistically significant.

Calcium and magnesium

Differences between farms were significant for calcium content, ranging from 1 125.76 to 2 019.04 mg/kg, but not for magnesium content 136.02–196.67 mg/kg. Calcium content correlated with fat content ($R = 0.647$).

Iron, zinc, copper and manganese

Iron, zinc, copper and manganese contents in milk from different farms were statistically different. Relatively high coefficients of correlation of manganese and copper with the other three minerals were obtained (Mn – Fe: $R = 0.641$, Mn – Zn: $R = 0.731$, Mn – Cu: $R = 0.618$, Cu – Fe: $R = 0.613$, Cu – Zn: $R = 0.629$) while the contents of iron and zinc were not so highly correlated. In addition, correlations existed between copper and calcium content ($R = 0.629$) as well as between

Table 1. Instrumental conditions for lead, cadmium, calcium, copper, iron, manganese, magnesium and zinc determination in raw cow's milk by FA-AAS

	Lead	Cadmium	Calcium	Copper	Iron	Manganese	Magnesium	Zinc
Primary wavelength (nm)	217.0	228.8	422.7	324.8	248.3	279.5	285.2	213.9
Band-pass (nm)	0.5	0.5	0.5	0.5	0.2	0.5	0.5	0.5
Injection volume (ml)	1	1	1	1	1	1	1	1
Flame type	air/acetylene							
Fuel flow rate (l/min)	0.9-1.2	1.0-1.3	0.9-1.2	0.8-1.1	0.8-1.0	0.9-1.2	0.9-1.2	0.9-1.2
Sensitivity (mg/l)	0.10	0.032	0.09	0.041	0.060	0.029	0.003	0.013

Table 2. ANOVA summary of the farm effect on mineral levels in raw cow's milk. Means with the same letter are not significantly different

	Protein	Fat	Ca	Mg	Fe	Zn	Cu	Mn	Pb	Cd
	(%)									
P	<0.0001	<0.0001	0.0011	0.5022	0.0050	<0.0001	<0.0001	0.0069	0.0007	<0.0001
Farm	(%)		(mg/kg)			(µg/kg)				
I	2.81 ^a	3.15 ^{ab}	1 151.62 ^a	141.53	0.10 ^a	0.31 ^a	0.20 ^a	0.026 ^a	23.06 ^a	3.02 ^a
II	3.97 ^c	5.90 ^c	2 019.04 ^b	196.67	0.14 ^b	0.83 ^b	0.69 ^d	0.055 ^b	70.56 ^b	5.47 ^{bcd}
III	3.22 ^{abc}	4.23 ^b	1 463.57 ^{ab}	162.34	0.12 ^{ab}	0.49 ^a	0.40 ^{bc}	0.043 ^{ab}	41.36 ^{ab}	6.09 ^{cd}
IV	3.32 ^{bc}	3.81 ^{ab}	1 314.40 ^a	161.21	0.13 ^{ab}	0.41 ^a	0.32 ^a	0.035 ^{ab}	29.61 ^{ab}	6.47 ^d
V	3.23 ^{abc}	4.08 ^b	1 384.77 ^{ab}	157.59	0.14 ^b	0.54 ^a	0.41 ^{bc}	0.040 ^{ab}	40.36 ^{ab}	5.65 ^{bcd}
VI	3.86 ^{de}	4.62 ^{bc}	1 588.46 ^{ab}	180.52	0.13 ^{ab}	0.64 ^b	0.39 ^{bc}	0.048 ^{ab}	43.50 ^{ab}	5.65 ^{bcd}
VII	3.23 ^{abc}	3.69 ^{ab}	1 401.71 ^{ab}	159.35	0.13 ^{ab}	0.50 ^a	0.43 ^{bc}	0.040 ^{ab}	37.53 ^{ab}	4.06 ^{ab}
VIII	3.17 ^{abc}	3.61 ^{ab}	1 094.49 ^a	153.61	0.12 ^{ab}	0.47 ^a	0.37 ^{bc}	0.040 ^{ab}	47.22 ^{ab}	6.12 ^{cd}
IX	3.41 ^{cde}	4.45 ^b	1 478.34 ^{ab}	196.18	0.13 ^{ab}	0.48 ^a	0.41 ^{bc}	0.044 ^{ab}	58.59 ^{ab}	5.63 ^{bcd}
X	3.06 ^{abc}	4.01 ^b	1 309.12 ^a	159.70	0.12 ^{ab}	0.39 ^a	0.34 ^{bc}	0.034 ^{ab}	32.51 ^{ab}	5.80 ^{cd}
XI	2.97 ^{ab}	3.89 ^{abc}	1 279.91 ^a	150.44	0.12 ^{ab}	0.38 ^a	0.31 ^a	0.033 ^{ab}	39.98 ^{ab}	5.46 ^{bcd}
XII	3.14 ^{abc}	3.54 ^{ab}	1 364.10 ^{ab}	162.88	0.12 ^{ab}	0.52 ^a	0.33 ^{bc}	0.039 ^{ab}	36.32 ^a	5.16 ^{bcd}
XIII	3.45 ^{bcd}	3.79 ^{ab}	1 389.10 ^{ab}	163.55	0.13 ^{ab}	0.63 ^b	0.31 ^a	0.043 ^{ab}	36.08 ^a	4.49 ^{abc}
XIV	4.10 ^e	4.38 ^{ab}	1 694.72 ^{ab}	193.60	0.16 ^b	0.63 ^b	0.48 ^c	0.052 ^b	56.43 ^b	4.91 ^{bcd}
XV	3.50 ^{bcd}	2.55 ^a	1 125.76 ^a	136.02	0.13 ^{ab}	0.49 ^a	0.32 ^a	0.039 ^{ab}	38.58 ^{ab}	5.67 ^{bcd}

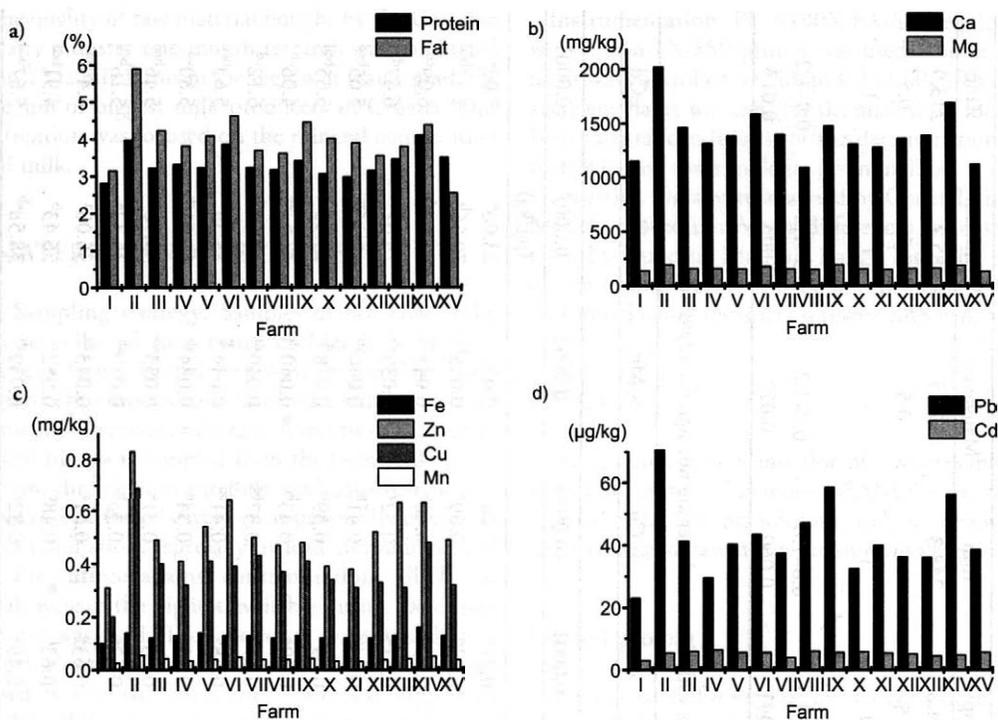


Figure 1. Composition of raw cow's milk from different farms: a) protein and fat; b) Ca and Mg; c) Fe, Zn, Cu and Mn; d) Pb and Cd

protein content and zinc ($R = 0.669$), copper ($R = 0.656$) and manganese ($R = 0.630$).

Lead and cadmium

Both lead and cadmium contents in milk from different farms were statistically different. No correlation was obtained between these minerals and other investigated parameters.

DISCUSSION

The concentrations of different essential minerals in milk from 15 farms included in this investigation can be arranged in the sequence $\text{Ca} > \text{Mg} > \text{Zn} > \text{Cu} > \text{Fe} > \text{Mn}$. This sequence is similar to that obtained by Rodríguez *et al.* (1999), the only difference being the sequence of Cu and Fe.

It is known that the metal concentration in milk can vary due the factors influencing its secretion from the mammary gland, such as breed of the animal, season of the year, feeding and factors related

Table 3. Average mineral composition of raw cow's milk from different countries

Country	Ca (mg/kg)	Mg (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	References
Italy			0.65	0.21	3.82	Del Petere, Di Stanislao (1984)
Spain	1 251 ± 48	116 ± 3	0.46 ± 0.10	0.16 ± 0.02	3.70 ± 0.22	Zuerera-Cosano <i>et al.</i> (1994)
Pakistan			0.60	0.45	4.20	Bano <i>et al.</i> (1985)
Croatia	1 403.94 ± 322.33	165.01 ± 37.97	0.13 ± 0.02	0.38 ± 0.12	0.51 ± 0.16	this paper

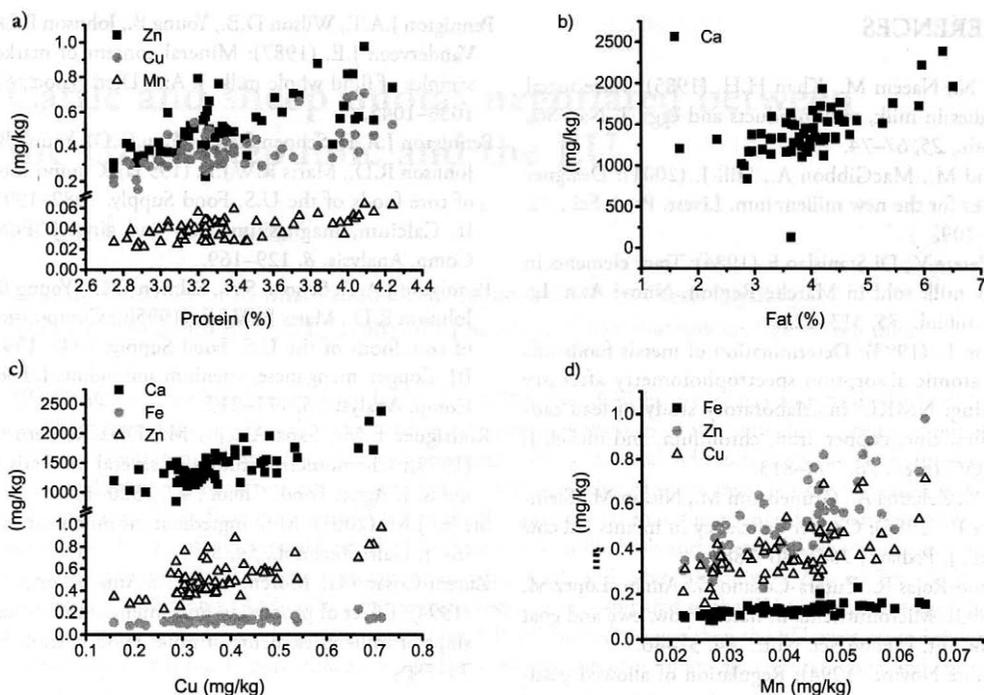


Figure 2. Correlations between: a) Zn, Cu, Mn and protein; b) Ca and fat; c) Ca, Fe, Zn and Cu; d) Fe, Zn, Cu and Mn in raw cow's milk from different farms

to animal handling by humans (Moreno-Rojas *et al.*, 1993; Zurera-Cosano *et al.*, 1994). In this study the animals on the farms were of the same breed, samples were taken in a relatively short period, cows were fed the same concentrate but different dry hay. Therefore the statistically significant differences in the content of essential minerals between the farms can be ascribed to different dry hays. Lead and cadmium are toxic minerals often associated with traffic pollution, therefore variations of their levels in milk from different farms are likely due to the location of meadows in relation to roads. Tolerance limits of these two toxic metals according to Croatian legislation are: Pb < 100 µg/l, Cd < 10 µg/l (Narodne Novine, 1994). Lead and cadmium levels in milk from all investigated farms were below these limits.

In comparison with the average mineral composition of raw milk obtained by investigations in Italy (Del Petre and Di Stanislao, 1984), Spain (Zuerera-Cosano *et al.*, 1994) and Pakistan (Bano *et al.*, 1985), milk from Croatian farms has more Ca and Mg, similar content of Cu and lower content of Fe

and Zn (Table 3). However, it should be noted that deviations are much larger in our investigation.

Relatively low correlation coefficients are in accordance with previous studies (Rodríguez *et al.*, 1999). This was explained by the relatively narrow range of metal concentrations found in certain types of milk.

CONCLUSIONS

Contents of essential minerals (Ca, Mg, Fe, Zn, Cu, Mn) in milk from Croatian farms are on the normal levels in comparison with the data from other countries. The statistically significant difference in their contents in milk obtained from different farms implies the necessity of controlling mineral levels in milk by the dairy industry. Lead and cadmium levels in milk from all investigated farms are below the limits as defined by the Croatian legislation, indicating a possibility of producing "organic" products.

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ABSTRAKT

Stanovení obsahu kovů v kravském mléce pomocí plamenové atomové absorpční spektrofotometrie

Obsahy základních kovů (Ca, Cu, Fe, Mg, Mn, Zn) a toxických kovů (Pb a Cd) v syrovém kravském mléce byly stanoveny plamenovou atomovou absorpční spektrofotometrií (FA-AAS). Vzorky mléka byly odebrány čtyřikrát v březnu v roce 2000 na 15 farmách poblíž Križe v záhřebské oblasti ze směsného mléka přímo do plastových lahví (aby se předešlo kontaminaci). Vzorky syrového kravského mléka byly podrobeny mineralizaci v mikrovlnném digesčním systému MLS-1200 Mega pomocí technologie MDR; obsahy kovů byly stanoveny přímo pomocí FA-AAS v roztocích vzorků, které prošly mineralizací. Ke statistickým analýzám byl použit statistický software SAS v. 8.0. Obsahy základních kovů (Ca, Cu, Fe, Mg, Zn) v mléce z chorvatských farem jsou ve srovnání s údaji z ostatních zemí na normální hladině. Hladina toxických kovů (Pb a Cd) byla nižší než povolené limity, které definují chorvatské předpisy (Pb < 100 µg/l a Cd < 10 µg/l).

Klíčová slova: olovo; kadmium; měď; železo; mangan; hořčík; vápník; syrové kravské mléko; plamenová atomová absorpční spektrofotometrie

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Cattle and sheep quotas negotiated between the Czech Republic and the EU

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ABSTRACT: Cattle quotas negotiated by the Czech Republic (CR) before its accession to the EU will influence for a long time not only the volume of cattle production and revenues in this agricultural segment, but also they will have a significant influence on the use of permanent grassland, social indicators, employment in the agricultural sector and other related sectors and services, as well as on a number of other areas. For the successful fulfilment of the above mentioned functions, the CR has markedly lower quotas than the existing EU member countries. Calculated per 100 ha of agricultural land, the Czech quotas for milk, bulls and steers, suckler cows, ewes (and goats), total livestock units, and slaughter premiums on adult cattle and calves are only 72.7%, 83.7%, 26.3%, 2.7%, 49.0%, and 64.7% and 13.6% of the EU average, respectively, compared to the EU aggregate averages. It follows from the above comparison that the quotas for the CR are markedly lower than the EU average, and therefore the country will find it much more difficult to meet all the objectives of common agricultural policy and cope with its tasks than the existing EU countries.

Keywords: agricultural policy; production quotas; milk; slaughter cattle; agricultural land; permanent grassland; Czech Republic; EU; comparison

The main objective of cattle producers both in the CR and in EU countries is to achieve the goals of agricultural policy and to earn an adequate income. To achieve these goals, the EU set down price, intervention, trade, regulatory, marketing, subsidy and other rules for cattle and sheep production that are listed in Council Directives 1255/1999 (milk and dairy products), 1254/1999 (beef and veal) and 2529/2001 (sheep, mutton and goat meat). The system of direct payments, interventions, consumption enhancement programmes, extensification programmes and other measures in effect in the EU for an extended period of time has created better conditions for cattle and sheep producers than those of producers in most candidate countries. The opportunity to join the common market within the framework of the European model of multifunctional agriculture provided an impetus for Czech producers to start working on problems connected with the necessary transformation of the agricultural sector.

The Czech Republic began to prepare for accession to the EU in January 1996, when the Council of Ministers accepted its application to join the EU. The principles of common agricultural policy set down by the respective legislation, European model of multifunctional agriculture set by Agenda 2000, and the principles of equal access created the hope that after overcoming the long agricultural recession in the CR it will be possible, in the EU conditions, to guarantee an appropriate development of both plant and animal production in order that the tasks defined by national needs and the EU agricultural policy objectives could be reached. In view of dramatic reduction in cattle herd sizes and in the production of cattle and sheep since 1989, and because of their importance for the settlement of rural areas and for the maintenance of the countryside in its natural as well as cultural shape, it was expected that there would be an adequate improvement of the existing situation in this especially important "sector" of animal production after accession to the EU.

The accession negotiations of the CR and the other nine candidates were concluded at the European Council session in Copenhagen in December 2002 by signing the final protocols. Difficult negotiations on agricultural issues were completed at the same time, and the agreed-on quotas and limits defined, among other things, the dimensions of cattle and sheep production in the CR after its accession to the EU.

This paper gives a brief analysis of negotiated cattle and sheep quotas from the aspect of the needs and actual situation in the CR, a comparison with the existing EU countries, production of different species and categories of animals, possibilities for the use of permanent grassland, levels of direct payments and the fulfilment of goals and tasks of the agricultural sector.

MATERIAL AND METHODS

Our analysis of cattle and sheep production under the EU conditions is based on the quotas requested by the CR and those negotiated with the EU representatives, on comparable indicators of the existing EU countries, and on the goals and tasks to be fulfilled by the agricultural sector on the national and EU levels. The data were taken over from Czech official documents (Position Document of the Czech Republic – the chapter on agriculture, negotiated quotas, data from the Czech Bureau of Statistics, commodity studies of the Ministry of Agriculture, etc.) as well as from EU documents (directives of the Council and the Commission, Eurostat Data, publications by the ZMP-Marktberichststelle Berlin, EU statements, etc.). To reach comparability, all selected indicators and economic data from the CR and EU were calculated per unit area of agricultural land or grassland. Because different values were reported for some parameters, the values shown should be taken as approximations only. For financial data, the exchange rate 1 Euro (€) = 30 Czech Crowns (CZK) was used.

RESULTS

Development of main indicators in the agricultural sector and cattle production in the CR

After a significant downward trend that started in 1989, gross agricultural production suffered a further decrease of 6.6 billion CZK in constant prices (8.2%) between 1996 and 2000. In 2001, it regis-

tered an annual increase of 2.1 billion CZK (2.8%). This increase occurred in plant production only (7.4%); animal production recorded a slight decrease (0.7%). Cattle production (milk and beef) in 2002 remained on the same level as in 2001. In spite of some current (mainly economic) problems, agriculture successfully fulfils the tasks of supplying enough good quality food, but the current size of cattle and sheep herds does not allow for a sufficient fulfilment of its non-production and social functions.

The decrease in the number of workers in agriculture was even more marked than the decrease in agricultural. The number of workers in agriculture, forestry and fishing industry dropped by a half between 1989 and 1994; and by 2001 their number dropped to about 68% of the 1996 figure. The decrease in the number of workers was also reflected in increased productivity of labour.

The long-term development of wages has not been positive in agriculture. While the average monthly salary the Czech Republic increased by 336% between 1989 and 2001 (from 3 183 to 13 882 CZK), wages in agriculture rose only by 219% (from 3 457 to 11 016 CZK). In 2001 wages in agriculture amounted to only about 80% of average Czech monthly salaries. The development in 2001, however, can signal a change for the better: while the annual increase in average salary in the CR was 391 CZK (2.9%), average salary in agriculture rose by 969 CZK (9.6%).

Positive aspects of dairy cattle production are an increase in annual milk yields per cow from about 4 095 kg in 1994 to 5 860 kg in 2002, and a gradual increase in marketability, domestic consumption and purchase prices of milk in recent years. Domestic production sales have been pushed down by the increasing proportion of dairy product imports since 1994. A drop in the number of dairy cows by about 65% between 1989 and 2002 is also negative (Table 1). Slaughter cattle production is characterized by a long-term decrease in numbers of all cattle categories (with the exception of suckler cows), in production and consumption of beef, and by unsatisfactory economic results. In the last three years, beef production and consumption indicators have been negatively influenced by BSE.

Brief analysis of cattle and sheep quotas

In spite of a marked reduction in the size of its herds, from the long-term aspect the CR is self-

Table 1. Basic parameters of milk production in the CR

Indicator	Unit ¹	1989	1996	1998	2000	2001	2002 ²
Dairy cows	1 000 head	1 248	657	562	515	483	480
Average milk yield per cow	kg	4 101	4 429	4 982	5 413	5 757	5 861
Milk production	mil. kg	5 039	3 130	2 797	2 789	2 783	2 813
Milk supplies	mil. kg	4 607	2 611	2 543	2 589	2 608	2 616
Domestic consumption	mil. kg	3 172	1 966	1 938	2 083	2 093	2 153
Milk imports	mil. kg	–	144	109	194	209	237
Milk exports	mil. kg	1 435	798	697	689	723	680
Rate of self-sufficiency	%	145	133	131	124	125	121
Purchase prices (Class I)	CZK/100 kg	5.15	7.11	8.12	7.67	8.08	8.34

¹volume units (litres) are converted to kg using the quotient 1.03; ²preliminary data

Table 2. Survey of negotiated and requested ceilings for cattle and sheep

Description	Measure unit	Negotiated ceiling	CR request	Negotiated ceilings (%)	
				CR request	present situation ¹
Milk quota	tons	2 737 931 ²	3 100 000	88.3	104.6
Dairy cows ³	1 000 head	480.0	543.8	88.3	104.6
Bulls and steers	1 000 head	244 349	305 000	80.1	116.4
Suckler cows	1 000 head	90 300	230 000	39.3	90.3
Slaughter adult cattle	1 000 head	483 382	530 000	96.4	121.6
premium calves	1 000 head	27 380			
Sheep	1 000 head	66 733	130 000	51.3	69.5

¹preliminary data for 2002 or estimates; ²of which 55 788 tons (2.0%) as a reserve starting in 2006; ³calculation based on the annual market production of 5 700 kg milk per cow

Table 3. Comparison of ceilings for cattle and sheep between Austria and CR

Parameter	Measure unit	Austria	CR	Index ¹
Population	mil.	8.1	10.3	127
Agricultural land	1 000 ha	3 415	4 280	125
Milk quota	mil. kg	2 740.4	2 737.9	99.9
Slaughter bulls and steers	1 000 head	423.4	244.3	57.7
Suckler cows	1 000 head	325.0 ²	90.3	27.8
Sheep	1 000 head	206.0	66.7	32.4
Livestock units, total ³	1 000 LU	779.3	344.6	44.2
Slaughter adult cattle	1 000 head	546.6	483.4	88.4
premium calves	1 000 head	129.9	27.4	19.0

¹Austria = 100; ²about 78% of the national ceiling for suckler cows was used in Austria in 2000; ³total number of LU of bulls and steers, suckler cows and sheep

sufficient in all cattle products used for human consumption. As ruminants play an important role in the use of agricultural land and permanent grassland (PG), the assessment of cattle and sheep quotas is primarily focused on stocking rate parameters, i.e. on the numbers of animals and livestock units per unit of land or PG.

It follows from Table 2 that all the quotas negotiated with the EU are lower than those requested by the CR. Nearest to the required level are slaughter premiums for cattle (96.4%), milk quota for 2006 (88.3%) and numbers of slaughter bulls and steers (80.1%). The biggest gap between the required numbers and the negotiated quotas is in categories that entail subsidies from the EU budget, i.e. in quotas for sheep (51.3%) and suckler cows (39.3%). Compared with the current situation, negotiated quotas will enable a slight increase in milk production by 2006 (by about 4.6%), and an increase in the number of slaughter bulls and steers (by about 16.4%). On the other hand, only about 70% of sheep and about 90% of suckler cows (and heifers) currently kept in the Czech Republic will be eligible for direct payments.

Because of the need for an adequate use of agricultural land and PG, employment rates, rural development and other social and environmental aspects, the Czech milk and other quota requirements were defined as minimum requirements, and no major change in these quotas can be expected in the nearest years of the Czech membership in the EU. From the aspect of the possibility to use PG and relatively high subsidies, particularly "painful" is the reduction

in the number of suckler cows, especially in relation with the necessary extension of PG.

Comparison with quotas in the EU countries

A comparison of absolute figures of cattle and sheep quotas is meaningful only between the countries of similar size and natural conditions. Because Austria fits those requirements for a comparison with the CR best, Table 3 shows a comparison between Czech quotas and those of our southern neighbours.

Although Austria has 20% less agricultural land and 21% less population than the CR, the only comparable quota is that of milk. Other Czech quotas are lower, some are markedly lower (slaughter premium for calves 19%, suckler cows 28% and sheep 32.4% of the Austrian quotas). The quotas of livestock units (LU) of bulls and steers, suckler cows and sheep for the CR are only 45% of those for Austria. These figures suggest how difficult the position of the CR will be trying to maintain its PG, especially in the less favoured (mountain and submontane) areas, in their natural and cultural shape because of the lower numbers of cattle and sheep and direct payments related to their numbers.

The comparison of quotas with all the other EU countries is possible when they are converted per unit area. As in the case of Austria, all Czech quotas for cattle and sheep are lower than weighted averages of the existing EU member countries (Figure 1). The largest differences between the EU average

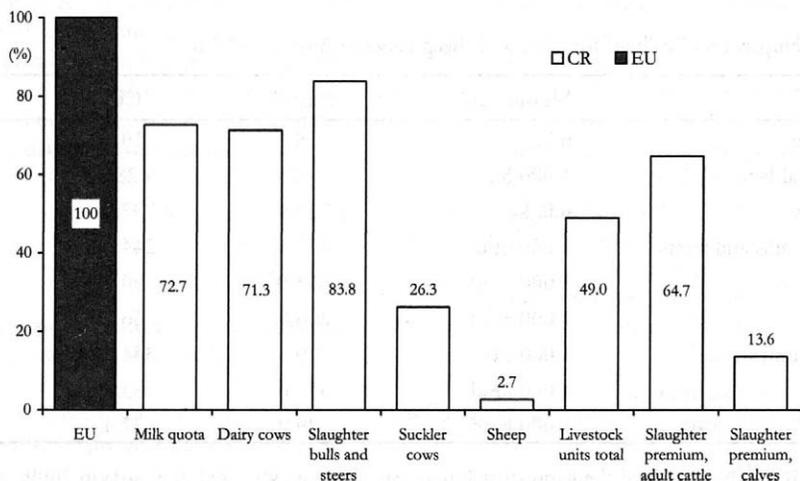


Figure 1. "Ceilings" for cattle and sheep (per 100 ha agricultural land) in EU and CR (EU average = 100)

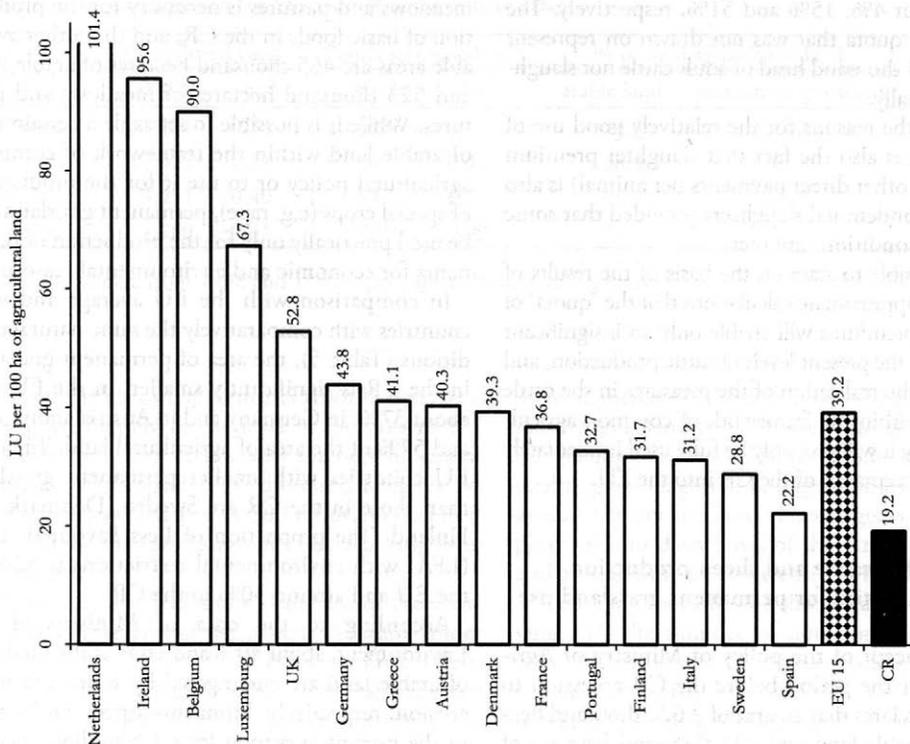


Figure 2. „Ceilings“ for cattle and sheep per 100 ha of agricultural land in the EU and the CR

and the CR, calculated per 100 ha of agricultural land, are for suckler cows (about 26% of the EU average), calf slaughter premiums (13.6%), and the quotas for sheep (2.7%). The Czech quotas for the livestock units of dairy and suckler cows, bulls and steers, sheep and goats per 100 ha agricultural land are about 50% of the EU average, and lower than those of any other member country (Figure 2). These data also indicate more difficult conditions for the achievement of national agricultural goals and for coping with tasks set by the European model of multifunctional agriculture than those enjoyed by the existing EU member countries.

Use of slaughter premiums

Slaughter premiums are direct payments within the quotas for all cattle categories. If the specified conditions are met, premiums per slaughtered animals or animals exported to the third countries are paid. The premiums are 80 € (2 400 CZK) per adult head of cattle (bulls, steers, cows and heif-

ers 8 months old or older) and 50 € (1 500 CZK) per calf (between 1 and 7 months of age, slaughter weight below 160 kg). After the ten-year transitional period the annual slaughter premium quota for the CR (483 383 head of adult cattle and 27 380 calves) will correspond to the total annual “subsidy” of about 1 200 million CZK.

A rough estimate of the possibility for Czech farmers to draw on the quota and payments is based on approximate current numbers of individual cattle categories in the CR, and a simplified national annual turnover in the herd. It follows from Table 4 that it is realistic to make approximately 96% use of the cattle slaughter premium quota (510 762 animals) if the expected numbers of animals (483 000 dairy cows, 90 000 suckler cows) and the cattle herd turnover (95 to 97 calves per 100 cows, 6 to 9% death rate in calves below 6 months of age, 1% for other cattle categories) are reached. Calf slaughter premiums would be made 100% use of; and the quotas for adult cattle, slaughter dairy cows, excluded suckler cows, heifers above 7 months of age, and bulls and steers above 7 months of age would be drawn on to

30%, about 4%, 15% and 51%, respectively. The 4% of the quota that was not drawn on represent about 20.5 thousand head of adult cattle not slaughtered annually.

One of the reasons for the relatively good use of this quota is also the fact that slaughter premium (as well as other direct payments per animal) is also paid for condemned slaughters provided that some specified conditions are met.

It is possible to state on the basis of the results of the above approximate calculations that the "quota" of slaughter premiums will enable only an insignificant increase in the present levels of cattle production, and that after the realization of the measures in the cattle segment within the framework of common agricultural policy it will probably be fully used immediately after the acceptance of the CR into the EU.

Ceilings for cattle and sheep production and possibilities for permanent grassland use

The concept of the policy of Ministry of Agriculture for the period before the CR accession to the EU declares that an area of 2 626 thousand hectares of arable land and 422 thousand hectares of

meadows and pastures is necessary for the production of basic foods in the CR, and that other available areas are 465 thousand hectares of arable land and 523 thousand hectares of meadows and pastures. While it is possible to set aside a certain area of arable land within the framework of common agricultural policy or to use it for the production of special crops (e.g. rape), permanent grassland can be used practically only for the production of ruminants for economic and environmental reasons.

In comparison with the EU average and with countries with comparatively the same natural conditions (Table 5), the area of permanent grassland in the CR is significantly smaller. In the EU it is about 37%, in Germany and in Austria about 30% and 57% of the area of agricultural land. The only EU countries with smaller permanent grassland than those in the CR are Sweden, Denmark and Finland. The proportion of Less Favoured Areas (LFA) with environmental restrictions is 52% in the EU and around 50% in the CR.

According to the data of Ministry of the Environment, about 40% and 10% of the total area of arable land are endangered by water and wind erosion, respectively. From this aspect, an increase in the present area to at least 1.5 million hectares

Table 4. Approximate numbers of cattle slaughters (model replacement of cattle herd)

Description	Cows			
	dual-purpose (C)	dairy (H)	suckler cows	total (Ø)
No. of cows	251 000	232 000	90 000	573 000
Herd replacement (%)	29	32	20	28
No. of slaughtered cows ¹	70 000	72 000	17 000	159 000
Birth rate (%)	97	95	96	96
No. of born calves	243 000	220 000	86 000	549 000
Death loss of calves below 6 months of age (%)	9	9	6	8
No. of 6 months old calves (%)	222	201	81	504
No. of 6 months old calves per 100 cows (%)	88	87	90	88
1 to 6 months old calves slaughtered ¹	13 000	11 000	3 000	27 000
Calves above 6 months of age ²	206 000	188 000	77 000	471 000
Heifers above 7 months of age slaughtered ¹	30 000	20 000	21 000	71 000
No. of slaughtered bulls ¹ , age above 7 months	103	94	38	235
Slaughters				
adult cattle	203 000	186 000	76 000	465 000
calves	13 000	11 000	3 000	27 000
in total ¹				
total	216 000	197 000	79 000	492 000

¹including emergency slaughters and after deducting the death losses of 1%; ²after deducting the death losses of 1%

Table 5. Land structure¹⁾ in the EU and CR (approximate data)

Country	Agricultural land		Permanent grassland		% of total agricultural land		LFA ³⁾ (%)
	1 000 ha	ha ²⁾	1 000 ha	ha ²⁾	arable land	permanent grassland	
EU total	135 831	0.36	50 443	0.13	54.8	37.2	52.0
Germany	17 373	0.21	5 265	0.06	68.4	30.3	49.9
Austria	3 411	0.40	1 943	0.24	40.6	56.9	68.6
CR (2001)	4 280	0.41	971	0.09	71.2	22.7	59.0

¹⁾most of the data from 1998 and 1999; ²⁾per capita; ³⁾less favoured areas

(35% of the area of agricultural land) is necessary, i.e. approximately to the level of the present EU member countries. That is why the present area of permanent grassland (970 thousand hectares) as well as the required area (1 500 thousand hectares) are used for the calculation of cattle stocking rates (densities).

Approximate calculations of the use of the existing and future area of permanent grassland under the conditions of the EU based on numbers of eligible animals and total number of animals are given in Table 6. The number of eligible animals in the case of dairy cows is the number that corresponds to a full use of the negotiated milk ceiling, and, in the case of other categories of bovines and sheep, the maximum number of animals (the ceiling) still eligible for a subsidy. In the case of “combined” cow population, it is expected that heifers and about 50% of cows will be reared on pasture, in the case of dairy herds, heifers will partly be reared on pasture together with about 10% of dairy cows. The area of permanent grassland per LU that can be considered as maximum includes also the rearing of other categories related to that animal category (calves, heifers, lambs). Unregulated numbers are based on estimates of the numbers of animals that will be reared in the CR outside of the framework of the quotas without any right to subsidies. They are for example: milk production (dairy cow rearing) for the farmer’s family, keeping of other categories of cattle and sheep aimed at the utilization of some small permanent grassland, horses kept mainly for sports and recreational reasons, hobby rearing of cattle, sheep and goats, farm management of red deer, rabbit rearing, etc. Other ways of using permanent grassland include mulching and harvesting of herbage and composting of grass. It is estimated that about 30 thousand hectares can be used in this way, i.e. about 3% of the existing per-

manent grassland. The definition of the area of permanent grassland per LU takes into consideration the grazing of animals and the production of high quality grass silage and haylage. Full-day grazing is assumed in suckler cows, horses, goats and sheep, partly also in dairy cows of the Czech Pied breed and a small number of extensively fattened steers.

The ceiling for cattle and sheep is about 830 thousand LU, the number of non-eligible animals is about 185 thousand LU. If the stocking density of animals per hectare listed in Table 6 is maintained, it would be possible to use about 745 thousand hectares of permanent grassland (87% of its registered area) in the CR. Of the total utilizable PG area, about 70% (524 thousand hectares) can be used for the eligible animals, 26% (191 thousand ha) for the non-eligible animals and 4% (30 thousand ha) for other uses (food for game, mulching, composting). Thus there is neither economic nor ecological use for about 13% of the registered permanent grassland area (i.e. 125 000 ha). If there is an increase in the permanent grassland area to 1.5 million hectares, the unused area would increase to about 775 000 hectares, which is about 18% of the total area of agricultural land. This fact is a serious problem for the Czech agricultural sector from the aspect of EU conditions even though the areas of permanent grassland used for animal production given in Table 7 should slightly increase thanks to the breeders’ positive attitudes, government policies and extreme extensification, and forests to be planted on a part of the PG area. The main problems of utilizing permanent grassland in a way other than for grazing (composting, mulching, biogas production, etc.) can be caused by difficulties arising from the practical realization of these “substitute” methods and their economic requirements, and possibly also by their negative impact on the environment. If only a limited area of permanent grassland can be used reason-

ably from economic and ecological points of view, it would then be necessary to assess the possibility of further conversion to pastures and afforestation.

The difficult utilization of permanent grassland in the CR is also confirmed by comparing the “density” of the ceilings of the numbers of suckler cows and sheep per 100 hectares with that in the EU countries. It follows from Table 7 that the numbers of suckler cows and sheep (i.e. the main “consumers” of permanent grassland) per 100 ha of permanent grassland are significantly lower than the EU average (22.9%) or the actual areas in Germany (54.2%) and Austria (56.3%), even at the present level of permanent grassland area. The increase in the area of permanent grassland to 1 500 ha would further negatively influence the rates of “eligible” suckler cows and sheep per 100 ha of permanent grassland (15% of EU average, and 35% and 37% of the actual situation in Germany and Austria, respectively).

It is evident from Figure 3 that the number of livestock units for sheep and suckler cows per 100 ha of permanent grassland in comparison with the existing EU member countries is the lowest both for the

existing acreage (970 000 ha) and the future (necessary) acreage of about 1 500 ha of PG.

DISCUSSION

In its official material (IP/02/1882), the EU stated that, based on the decision of the EU Council, headage limits for the candidate countries should be established on the basis of the historically latest reference period for which reliable data were available. In the cattle and sheep industry, such reference period includes probably the worst time segment of the long-term recession in the Czech agricultural sector.

It follows from the approximate evaluation of the negotiated production quotas and ceilings for the numbers of cattle and sheep that the agreed-on numbers of ruminants for the EU membership are insufficient and do not enable the agricultural sector to satisfactorily achieve its aims and tasks, particularly as far as the economic and environmentally friendly use of permanent grassland is concerned. That is

Table 6. Use of permanent grassland areas in the CR

Description	Headage (in 1 000s) ²		Permanent grassland (ha) per LU	Permanent grassland in total		
	head	LU		1 000 ha	%	
Quotas (national ceilings)	dairy cows ¹ – breed C	251.0	251.0	0.8	201	27.0
	dairy cows ¹ – breed H	232.0	232.0	0.4	93	12.5
	dairy cows, total ¹	483.0	483.0	0.6	294	39.5
	bulls and steers	244.3	244.3	0.3	73	9.8
	suckler cows	90.3	90.3	1.5	137	18.4
	sheep	66.7	10.0	2.0	20	2.7
	Total	–	827.6	0.6	524	70.4
Outside of quotas (national ceilings)	heifers	170.0	100.0	0.7	70	9.3
	cattle in total	50.0	50.0	1.0	50	6.8
	horses	25.0	35.0	1.5	52	7.0
	sheep and goats	50.0	7.5	2.0	15	2.0
	others (rabbits etc.)	–	3.0	1.5	4	0.5
Total	–	185.5	1.0	191	25.6	
Other uses of permanent grassland ³	–	–	–	30	40	
Total use of permanent grassland	–	1 013.1	0.7	745	100.0	

¹the number of cows calculated from the milk ceiling and market production of 5 700 kg milk per cow

²coefficients for calculation of LU: cows, bulls, steers = 1.0, heifers = 0.15, horses = 1.4

³hay production by huntsmen associations, for mulching, composting, etc.

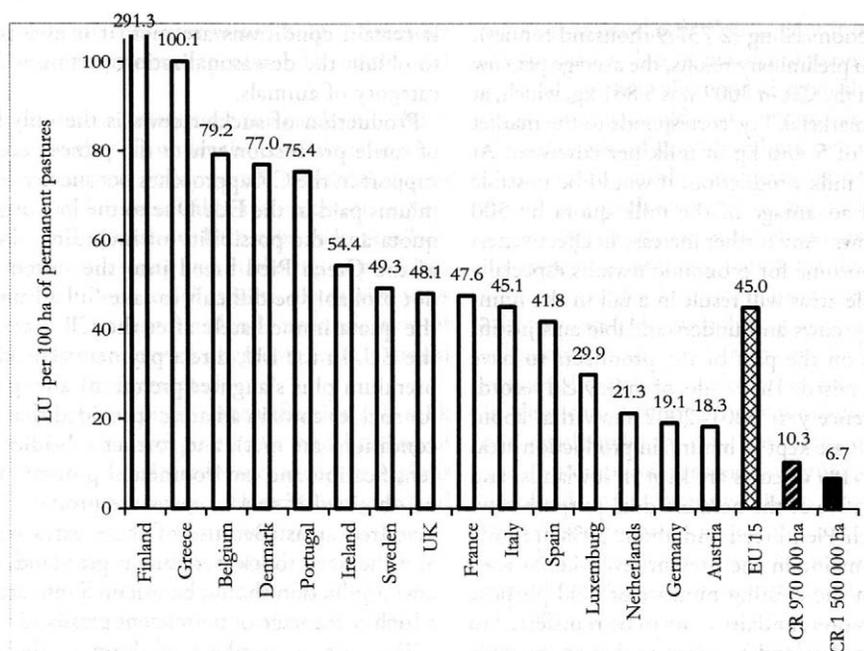


Figure 3. Ceilings of LU of suckler cows and sheep per 100 ha of permanent pastures in EU and ČR

why the Czech Republic will have to introduce a number of measures to help resolve this complicated situation to some extent at least. Because the goals of individual producers with an emphasis on profit generation and the interests of the society as a whole in the utilization of permanent grassland will not always coincide, mutual understanding and support of the general public will be necessary in order to reach the optimum stage.

The maximum profit in **milk production** is usually generated through high milk efficiency and by the use of specialized milk breeds in favourable natural and production conditions while the most of permanent grassland are in areas with less favourable conditions and usually lower milk efficiency. Table 8 shows the relationship between milk yields (market production of milk) and the numbers of cows necessary to take full advantage of the national

Table 7. Stocking densities of ruminants per 100 ha of permanent grassland in the EU and ČR

Description		Beef cows	Sheep (and goats)	Total
EU (LU)		21.5	23.5	45.0
Germany (LU)		12.1	6.9	19.0
Austria (LU)		16.7	1.6	18.3
Czech Republic (970 000 ha of permanent grassland)	LU	9.3	1.0	10.3
	% EU	43.2	4.3	22.9
	% Germany	76.9	14.5	54.2
Czech Republic (1 500 000 ha of permanent grassland)	% Austria	55.7	62.5	6.7
	LU	6.0	0.7	6.7
	% EU	27.9	3.0	14.9
of permanent grassland)	% Germany	49.6	10.1	34.2
	% Austria	35.9	43.8	36.3

milk production ceiling (2 737.9 thousand tonnes). According to preliminary results, the average per cow milk yield in the CR in 2002 was 5 861 kg, which, at the 93.5% marketability, corresponds to the market production of 5 480 kg of milk per cow/year. At this level of milk production, it would be possible to take full advantage of the milk quota by 500 thousand cows. Any further increase in effectiveness that will continue for economic reasons especially in favourable areas will result in a fall in the numbers of dairy cows and understandable and justifiable efforts on the part of the producers to have the ceilings raised. The results of milk yield records in the reference year 2001–2002 show that about 59% of cows are kept in mountain production areas and about 41% of cows are kept in lowlands, and that about 50% of the herd are dual-purpose cows of the Czech Pied breed and about 50% are milk breeds. To maintain the present level, i.e. at least to maintain the existing number of dual-purpose cows and to prevent dairy cows to be transferred to a better area (lowlands), measures that are possible under the EU legislation should be taken.

Of all cattle categories, the ceilings negotiated for the production of bulls and steers enable the largest increases in production compared with the present situation. Despite of the fact that it is an industry with a long-term decrease in sales (not only in the CR) and unsatisfactory economic results, measures for the full use of the negotiated ceilings should be taken – and not only because of direct payments from the EU budget. A possibility of steer grazing should be considered for better use of permanent grassland. Due to its extensive character and consequently often worse economic parameters of steer production compared with bull production, the EU set a higher premium per head for steers than for bulls (two special premiums of 150 € each, which is about 9 000 CZK).

If certain conditions are met, it is also possible to obtain the deseasonalisation premium for this category of animals.

Production of suckler cows is the only branch of cattle production where the present economic support in the CR approaches per suckler cow premiums paid in the EU. Due to the low negotiated quota and the possibility of including also cows of the Czech Pied breed into the system it will not probably be difficult to take full advantage of the quota immediately after the CR accession to the EU. In the EU, direct payments (suckler cow premium plus slaughter premium) are applicable for suckler cows in all areas (provided that certain conditions are met), and further subsidies for extensification and environmental programmes can be obtained if suckler cows are produced in less favoured areas. Because of these extra resources and the need to use permanent grassland, suckler cow production should be oriented into areas with a high percentage of permanent grassland.

The current **numbers of sheep** in the CR are about 40% higher than the negotiated ceiling of ewes eligible for a direct payment from the EU budget. It means that it will not be possible to include all the existing animals into the system of “subsidies”. The ceiling for the number of goats eligible for direct payments has not been decided. The production of mutton is one of the few agricultural commodities where demand in the EU countries exceeds supply (self-sufficiency of about 85%), and relatively significant volumes of mutton and goat meat are imported from the third countries. If good production and economic results are achieved in the industry of these small ruminants and if at least minimum economic support from domestic resources or from other sources is provided, a part of the production of mutton and lamb meat could also be marketed in the EU.

Table 8. Relationship between milk production and numbers of dairy cows¹

Description	Market milk production per cow/year				
	5 500	6 000	6 500	7 000	7 500
Dairy cows (1 000 head)	498	456	421	391	365
Dairy cows (%)	100	92	85	79	73
Permanent grassland (PG) per cow (ha)	0.7	0.6	0.5	0.4	0.3
Permanent total (1 000 ha)	350	275	210	155	110
grassland %	100	79	60	44	31

¹for the national milk quota

The following measures would help to improve the use of permanent grassland by cattle and sheep:

- To work out a strategy for the cattle and sheep segment in the CR under the conditions of common agricultural policy (cattle distribution into different regions that takes into account the use of permanent grassland, barn capacities, possibilities for the processing and marketing of products, employment and social aspects, alternative ways of using permanent grassland, extensification of production, strategy of payments from national and the EU budgets, etc.)
- To support adequate extensification of milk production (dual-purpose cows) and keeping of other categories of cattle and sheep in regions with a higher percentage of permanent grassland
- To consider the society's priorities in the first allocation of the national "ceiling" of suckler cows to individual producers and in the allocation of individual quotas from the national reserves
- To introduce grazing of steers
- To prevent the transfer of milk quotas and individual suckler cow quotas and sheep from specific (less favoured) areas
- To make it possible to produce cattle and sheep beyond the negotiated quotas and ceilings
- To support environmentally friendly systems of farming
- To take advantage of all programmes and projects subsidized from EU resources
- To support the activities of marketing organisations and the sales of domestic agricultural products
- To increase the quality of all the market products and respect consumers' requirements in order to increase the sales of cattle and sheep products on domestic as well as foreign markets
- To prepare and introduce programs for the utilization of permanent grassland in other ways than for the production of cattle and sheep

CONCLUSION

It follows from the above figures and data that the negotiated ceilings for cattle and sheep after accession to the EU are significantly lower in comparison with the situation in the existing member countries and disadvantageous for the CR from production as well as economic aspects, mainly in view of utilization of the present and future (desirable) area of

permanent grassland. That is why it is essential to prepare and realize in practice, in compliance with national law and valid regulations of the EU, all the measures that would make it possible to meet the aims and tasks of agricultural policy on the national level as well as within the framework of the enlarged EU even with the low production ceilings. Besides those mentioned above, the measures can include for example careful preparation for the complicated and demanding implementation of the rules of common agricultural policy, maximum utilization of resources allocated from the EU budget for structural measures, resolution of agricultural issues in close connection with environmental protection and development of rural areas, support to the sale and consumption of domestic agricultural products and foods, more intensive efforts at the resolution of agricultural problems on the level of newly established administrative regions, and support of the agricultural sector from the appropriate authorities, professional organisations and the society.

Despite of the less than optimistic evaluation of the ceilings negotiated for cattle and sheep production, which is only a part of the agricultural sector, it is necessary to make a joint effort to reach the situation which was outlined by the EU representatives in their statement at the end of accession negotiations. Among other things, they stated that "...in each of the ten new member countries of the Union, the agricultural sector would have better conditions than it had before now. The producers and processing companies would have an access to a larger market with 500 million consumers. In the common agricultural policy there would be more stable prices, which would result in higher stability of agricultural incomes. The farmers and rural areas would profit from higher resources allocated to rural areas that would enable transformation and modernisation. With the accession to the EU, the new member countries would obtain a seat at the table where decisions important for the whole Europe were made, and they would take part in making decisions about the way how Europe would function..."

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ABSTRAKT

Kvóty v chovu skotu a ovcí vyjednané mezi Českou republikou a EU

Českou republikou vyjednané regulované ukazatele chovu skotu pro podmínky EU budou dlouhodobě ovlivňovat nejen objem produkce a tržeb tohoto agrárního odvětví. Významný vliv budou mít na využívání trvalých travních porostů, na sociální ukazatele, na zaměstnanost v agrárním sektoru, v navazujících sektorech a službách a na další oblasti. Pro úspěšné plnění uvedených funkcí má ČR zřetelně nižší ukazatele než stávající členské státy unie. V přepočtu na 100 ha zemědělské půdy dosahují následující přibližné podíly průměru stejných ukazatelů v EU: mléčná kvóta 72,7 %, býci a volí 83,8 %, krávy bez tržní produkce mléka 26,3 %, bahnice (a kozy) 2,7 %, dobytčí jednotky celkem 49,0 % a porážkové prémie na dospělý skot a na telata 64,7 % a 13,6 %. Proto je nezbytné v souladu s národní legislativou a předpisy EU v praxi realizovat veškerá opatření, která by i při nízkých produkčních kvótách umožnila uspokojivé plnění cílů a úkolů zemědělské politiky na národní úrovni i v rámci rozšířené EU.

Klíčová slova: zemědělská politika; produkční kvóty; mléko; jatečný skot; zemědělská půda; trvalé travní porosty; možnosti využití; Česká republika; Evropská unie; srovnání

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