Grass-Fed Cattle as an Option to Improve the Sustainability of Cattle Industry in Croatia

Grass-Fed način hranidbe goveda kao opcija za poboljšanje održivosti govedarske proizvodnje u Hrvatskoj

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Scientific review
Pregledni znanstveni članak

SUMMARY

In Croatia, as well as in many neighboring countries, neither the cattle farmers nor the general public (i.e., the consumers) are familiar with the meaning of the grass-fed cattle farming. This paper's objective is to present what environmental and consumer-health benefits might arise from this way of cattle farming, along with the expected constrains regarding a lower productivity per animal and per the used land resources. The presented literature review has demonstrated that, when compared to the conventional TMR-fed cattle, the grass-fed feeding manner produces the cattle-derived foods with the greater consumer-related health benefits, has a potential to restore biodiversity in agricultural countryside, causes a lesser environmental pollution due to a lesser pesticide use, improves animal welfare and the beauty of a countryside landscape, decreases the farmers' operating costs, consumes less fossil fuel per hectare of the utilized land, which is appreciated in climate policies, and has a potential to improve the cattle farmers' resilience and independence from distant fossil fuels. The grass-fed foods are appreciated by the end-consumers who are willing to pay a price premium for such products. The projected feed and forage consumptions, along with the data on a grass-fed cattle productivity, have indicated a poorer conversion rate of feed DM to milk (1.433 vs. 0.756) and bodyweight gain (12.168 vs. 7.526) in the grass-fed cattle when compared to the TMR-fed, which implies that the grass-fed cattle would require much more land resources per product unit than the TMR-fed cattle. Further research is required to test the productivity of grass-fed cattle (per head and per hectare) in Croatian conditions, as well as to investigate the productivity of Croatian grassland resources.

Keywords: grass-fed cattle, environment, biodiversity, consumer health, energy, carbon emissions, climate

INTRODUCTION

Along with the entire conventional agriculture, cattle industry nowadays is being accused for threating the sustainable development of humanity due to the GHG emissions, environment pollution, and a loss of biodiversity. However, cattle breeding has a long tradition in Croatia, and it was much more important in the history than it is at present. In the first third of the 20th century, there were about 1 million head of cattle (CBS 2003).

According to the same source, agricultural land area at the end of 20th century amounted to approximately 3.15 million ha, with 1.46 million ha thereof being the arable land and 1.55 million ha being the permanent grasslands. Currently, there are only about 480 thousand head of cattle (CAAF, 2022). Croatian used agricultural land area presently amounts to 1.5 million ha, with the arable area amounting to approximately 0.85 million ha, whereof only approximately 0.6 million ha of permanent grasslands are utilized (CBS, 2018). The Croatian contribution to the EU cattle sector is relatively minor (EU counts approximately 76 million head, CAAF, 2022). Since a wide industrialization of the Croatian cattle sector by the end of 20th century, grazing cattle has become a very rare scene in Croatia, except in the mountainous region, where is being raised a minority of the Croatian cattle. Despite the fact that the cattle are the principal herbivore grazers that evolved on the large grasslands (among other large herbivores), adapted to consume the cellulose-rich forages and occasionally just a little of wild grass seeds, nowadays the majority of cattle are being fed contrary to their nature: they are fed by the fermented

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(acidified) forages (i.e., silages) and much of the starchy grains that are also being fermented in the rumen to produce organic acids. The resulting excessive acidity is associated with mastitis (udder inflammation, Hu et al., 2022), and laminitis (hoof disorder, Burger, 2017), polioencephalomalacia (neurologic disease), and liver abscesses (Owens et al., 1998). Mastitis and laminitis are currently the economically most important diseases in dairy cattle (Wells et el., 1998; Kučević et al., 2022; Gantner et al., 2023), since they impair the microeconomics due to the herd replacement and veterinary costs for animal healing. A better situation is not observed in a modern, feedlot beef-cattle fattening: a bovine respiratory disease and the digestive disorders have become the main animal-health problems, which also stem from an excessive intake of starchy concentrates (i.e., of the cereal grains) and consequential excessive acidity, with the associated treatment costs (Malafaia et al., 2016). Animal welfare in modern cattle industry is additionally impaired because of a lack of livestock's ability to live a "natural life" (Spooner et al., 2023)—that is, the cattle miss its natural movement on pastures, which has been substituted by an in-stall confinement. With an aim to make the cattle rearing more natural and environment friendly, and to produce the cattle-derived foods with a distinct quality (rich in vitamins and with a beneficial ratio of omega-3 and omega-6 fatty acids), a new way of certified cattle rearing, the one that enables the cattle to be fed on the forages only (as neither grains nor other concentrates are allowed in the diet) and with requirement for cattle to be pastured during the entire grazing season commenced at the end of 20th century in the USA. Such a way of cattle rearing was named "grass-fed cattle" and was soon expanded to other continents (Australia, South America, western Europe, and New Zealand). The acceptance and continuous increase of such way of cattle farming is achieved mainly due to the two leverages: 1) the consumers who are willing to pay the premium price for the healthier foods and more environment-friendly farming practices; and 2) the decreased costs of consumed forages (since pasture is the cheapest forage) and lesser capital investments (cheaper housings and lesser storage capacity due to a lesser consumption of stored fodder, etc.). In Croatia, as well as in many neighboring countries, neither the cattle farmers nor a general public (i.e., consumers) are familiar with the meaning of the grass-fed cattle rearing. Therefore, the aim of this paper is to present what environmental and consumer-health benefits might arise from this way of cattle farming, along with the expected constrains regarding a lower productivity per animal and per the used land resources. This might be specially interesting due to the rise of popularity of a low-input farming in Europe, since the grass-fed cattle rearing substantially relies on the use of the on-farm resources, with minimum external inputs and a minimum use of fossil fuels (due to a great share of the grazed forage).

Consumer-health benefits and consumers' preference

According to the synthesis effectuated by Alothman and colleagues (2019), milk from the grass-fed cows has an improved nutritional status, that is, a higher polyunsaturated fatty-acid content and a better omega-3-to-omega-6 ratio when compared to the milk of the TMR-fed cows, whereas the grazed cows produce milk with an increased content of vaccenic acid, conjugated linoleic acid, beta-carotene, and alpha-linolenic acid, which are all the health-beneficial nutrients. Butter from the grass-fed cows' milk was proven to be more appreciated by consumers than the one from the TMR-fed cows, mainly due to its distinguishing appearance, flavor, and color (O'Callaghan et al., 2016), while the grass-fed milk has a grassy, cowy, and barny flavor (Alothman et al., 2019), which might be preferred, or might not be preferred, by the consumers, depending on a personal specificity. A beneficial ratio of omega-3-to-omega-6 fatty acids in the grass-fed milk and meat has a potential anti-inflammatory effect to a consumer, while the anti-cancerogenic and cardioprotective phytochemicals are also detected in the grass-fed milk and meat (van Vliet et al., 2021.). According to the same source, the milk and meat from the cattle that grazed on the plant-species rich pasture can contain the additional health-promoting compounds like terpenoids, phenols, carotenoids, and antioxidants.

A market research conducted in Italy has revealed that the consumers had an increased propensity to the grass-fed milk (Peira et al., 2020) despite a higher retail price. On the other hand, a market research conducted in the USA (Wong et al., 2010) has revealed that a willing-to-pay the premium price for the grass-fed dairy products depends on a family's income, and the richer families were willing to pay a higher premium. According to the USDA National Monthly Grass Fed Beef Report (USDA, 2024), the average retail prices for the grass-fed beef might approximately double those for a conventional commodity beef, but the price premium strongly depends on the meat category—that is, on a specific part of the carcass. Considering the grass-fed milk, there is an anticipated continuous growth of this market in the forecasted period from 2023 to the year 2029 (FII, 2023).

CARBON EMISSIONS FROM POWERING THE FODDER PRODUCTION AND SOIL-RELATED ORGANIC-MATTER OXIDATION

A principal content of the daily ration for the TMR-fed dairy cows can be depicted from the ration used in research by Kolver and Muller (1998) in Pennsylvania (USA). Their high-yielding dairy cows in a peak lactation were fed by a ration which (in the dry matter, DM) consisted of 24 % of the whole-crop maize silage, 19 % of leguminous silage, 4 % of leguminous hay (47 % of forage in total), and 25 % of maize grain, while the rest were mainly the plant-protein concentrates, minerals, and vitamins. Only 23 % of the consumed DM came from the perennial forage legumes, while the remaining majority came from the annual arable crops of maize and protein-rich oilseeds. These annual arable crops in Croatia are still generally established on the plowed land, which is associated with a considerable soil respiration (Liu et al., 2022), soil organic matter oxidation, and consequential CO_2 emissions associated with the soil's organic matter loss, contrary to the perennial arable crops, which sequester the atmospheric carbon into the soil's organic matter.

The researches in the Pannonian climate (Moitzi et al., 2021a; 2021b) have revealed that the average direct diesel-fuel consumption amounts to approximately 82 liters per hectare (i.e., approximately 68 kg/ha) annually in a conventional technology (implying stubble cultivation, plowing, seedbed preparation, seeding, fertilizer spreading, herbicide spraying, harvesting, transportation, and residue chopping) in the production of maize grain (which is the most important concentrate feed for cattle), while for the spring-seeded soybean oilseed crop (which is used for the production of soyabean meal, the most important protein concentrate in the dairy cows rations in Croatia) an annual direct diesel-fuel consumption amounted to approximately 60 liters per hectare (50 kg/ha) in a conventional technology (including the moldboard plowing, seedbed preparation, seeding, herbicide spraying, harvesting, transportation, and stubble cultivation). If it is assumed that the combustion of 1 kg of diesel fuel releases 3.15 kg of CO_2 into the atmosphere, the CO_2 emissions from a direct diesel-fuel consumption in maize and soyabean crops can be estimated at 214 kg/ha and 158 kg/ha, respectively.

A research from Italy (Todde et al., 2018) has revealed that an average direct diesel-fuel consumption per hectare of lucerne crops amounted to 163 kg/ha (for a mixed use of hay and haylage), while it amounted to 171 kg/ha for the whole-crop silage maize. So great consumption of diesel fuel in these forages production was caused by the multiple annual hay and haylage harvests in lucerne and by an energy-demanding harvest, transportation, and packing of the whole-crop maize herbage. The respective CO_2 emissions from lucerne and silage maize amounted to 513 and 539 kg/ha, respectively.

Opposite to the arable crops used for the stored fodder production (maize for the grain and a whole-crop silage, soybean for a soyabean meal, and lucerne for hay and haylage production), a diesel fuel consumption used for grazing cattle is near to zero. Namely, diesel fuel is being used only for the transportation of potable water to the cattle—that is, for the transport of water from the well to the grazed paddock.

Since the combustion of diesel fuel releases considerable amounts of CO_2, a shift from the entirely stored fodder in the TMR-feeding systems to the grazed forage can bring the cattle industry closer to the objectives of climate policies, as well as make the cattle farmers less dependent on the distant and finite fossil-energy resources. However, the grazing season in Croatia and in the neighboring countries lasts about half a year (or little longer), thus limiting the fossil-fuel savings and CO_2 emissions to about half of the annual total, with a potential to save more by the synchronization of the greatest nutrition needs, with the greatest availability of herbage on pasture. Additional savings of fossil fuels are expected due to a lesser need for farmyard manure transportation and spreading, amounting to approximately a half of an annually produced quantity, since the grazing livestock deposits its own dung and urine on the grazed land during the grazing season.

Biodiversity issues and pesticide emissions

The production of annual arable crops, which is unavoidably associated with the TMR cattle feeding, makes our landscape looking like a desert for longer than half a year. A desert-like landscape is a hostile environment to many fauna species and soil microbiome, thus affecting a total biodiversity. Mueller and colleagues (2014) detected that the meadows and pastures were least harmful to biodiversity, followed by the permanent crops, while the arable land mostly affected biodiversity. Biodiversity is not affected only by the land use (annual arable vs. perennial forages) but also by pesticide emissions into environment (Demeneix, 2020). The annual arable fodder crops (maize and soybeans) are prone to the weed infestation, which requires a regular spraying of herbicides, while the perennial grass-clover leys do not need any herbicide treatments (Gantner et al., 2021). Based on these findings, a potential shift from the prevailing annual arable fodder crops to the perennial grazed forages is expected to restore biodiversity that was affected by many decades of intensive arable farming in continental Croatia and in the neighboring countries.

A shift to, or a reintroduction of, livestock grazing on an arable land also has a potential to avoid the losses from, and a need for control of, the field rodents in perennial forages. Namely, it is proven that the grazing livestock suppresses the field rodent populations (Steen, et al., 2005; Johnson and Horn, 2008; La Morgia et al., 2015).

According to the case study of the two opposite dairy cattle farms (a confinement TMR-fed vs. a pasture grass-fed-based one), a total environmental impact of a confinement dairy system was greater than that of a grass-based system (O'Brien et al., 2012). The assessment considered the on-farm plus the related off-farm pollutants and used resources per a unit of milk and per a unit of land area.

A SHIFT (TO SOME EXTENT) TO A GRASS-FED CATTLE WOULD BE ASSOCIATED WITH A POORER FEED-TO-MILK AND FEED-TO-BODY WEIGHT-GAIN CONVERSION RATE

Despite a possible shift (to some extent) from the TMR-fed to the grass-fed cattle would bring many environmental and consumer-related health benefits, a question arises of how would it be reflected on the feed-to-end product conversion efficiency.

Based on the feed dry matter intake (DMI) requirements for dairy cows expressed by Wheeler (1996, qtd. in Gantner et al., 2021), with some corrections according to the authors' experience in Croatian dairy farms that rear the Holstein breed (with an average milk yield of 8,543 kg per 305 days of lactation and 10,119 kg in entire lactation; CAAF, 2022), a projection of daily and cumulative DMI (Fig. 1) is presented below.

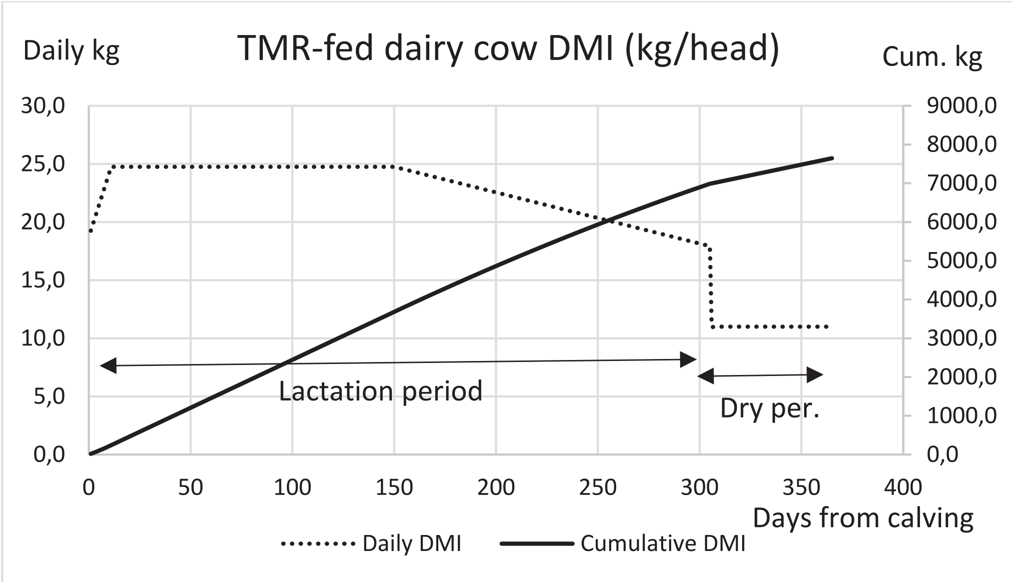

Figure 1. A projection of daily and cumulative DM intake in the TMR-fed dairy cows

Grafikon 1. Projekcija dnevne i kumulativne konzumacije suhe tvari kod muznih krava hranjenih TMR-obrocima

A DMI projection for the grass-fed dairy cows was drafted upon the data provided by Hibbard and Thrift (1992; qtd. in Lalman and Richards, 2014), as depicted in Figure 2. The annual milk yield is assumed to amount to 3,800 kg per cow (Darby et al., 2022).

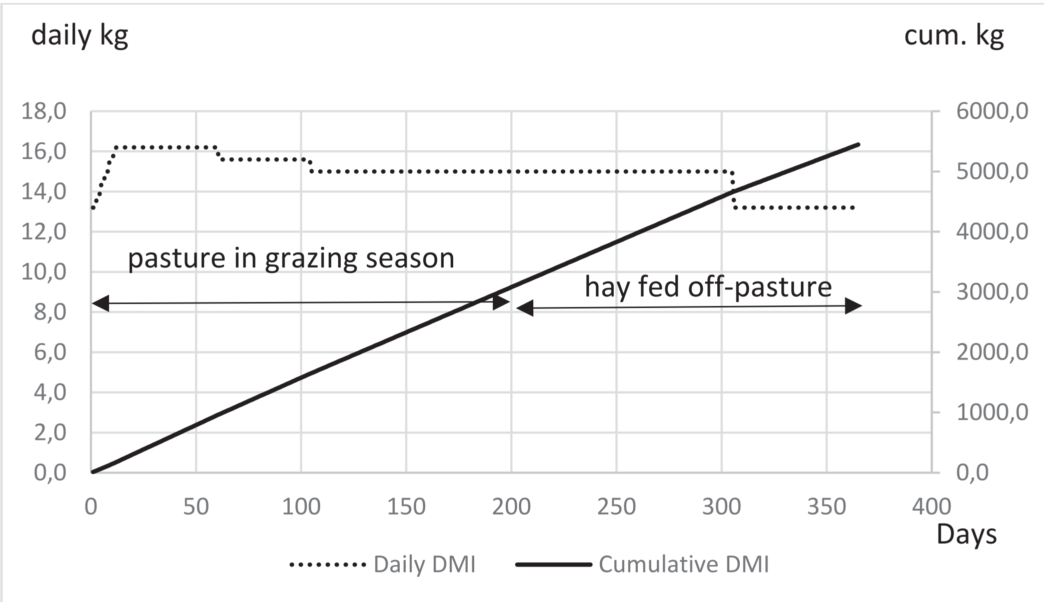

Figure 2. A projected daily and cumulative DMI (kg/head) for the grass-fed cows

Grafikon 2. Projekcija dnevne i kumulativne konzumacije suhe tvari grass-fed muznih krava

The highest daily DMI is projected for the vernal part of a grazing season (2.7 %, relative to the BW), with a gradual decrease to 2.5 %, along with the proximation of mid-summer and a drop to 2.2 during the cow's dry period in winter.

A projection for the TMR-fed fattening steers is based on the prevailing starting calf's body weight (BW) of 200 kg/animal and a BW gain in fattening steers detected in continental Croatia (according to the authors' own experience) during the ten months of fattening period (Fig. 3). The DMI for the TMR-fed steers is projected upon Lalman and Richards' (2014) reference (an average of 2.5 %, relative to the BW), as depicted in Figure 4.

A projection for the grass-fed steers fattening starts with a weaned, six-month-old calf of the BW amounting to 200 kg/head and ends with an eighteen-month-old steer of a BW amounting to 431.5 kg/head.

In line with Ringwall (2012), a North Dakota State University expert, the highest expected daily BW gain of the grass-fed steers is during the grazing season, and the least one during the winter off-pasture season. For the purpose of this research, a daily BW gain was assumed to be highest in the spring pasture (1.0 kg/head/day on the cool-season grass-clover mixes from mid-April till the end of June), somewhat lesser in the summer pasture (0.7 kg/head/day on lucerne plus the warm-season grasses pasture from the beginning of July till the end of August), and the least one in the fall pasture (0.5 kg/head/day in the cool-season grass-legume mixes from the beginning of September till mid-October) and winter hay feeding (0.5 kg/head/day in a high-quality hay feeding from mid-October till mid-April, Fig. 5).

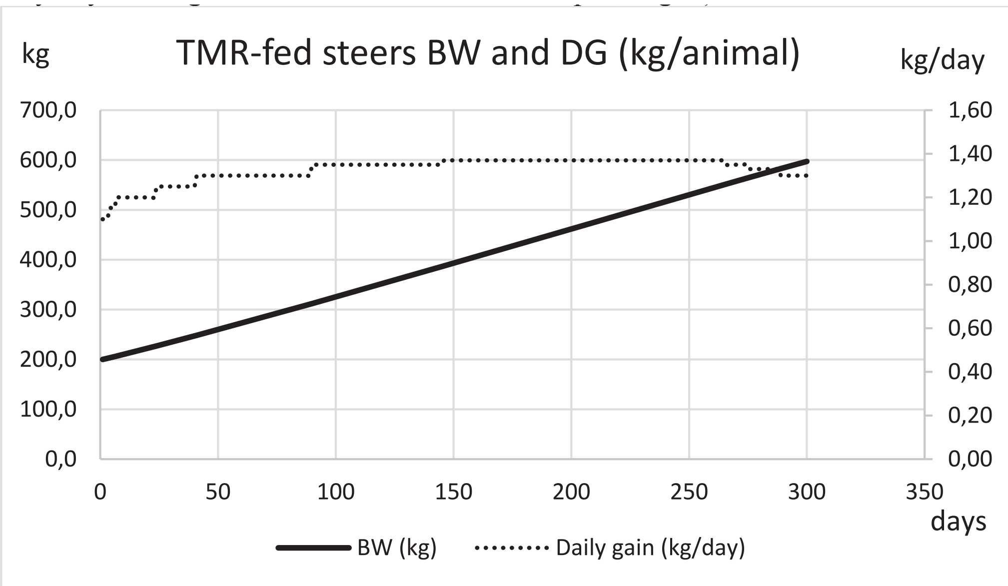

Figure 3. A Projection of the BW and of a daily gain of the TMR-fed steers

Grafikon 3. Projekcija aktualne tjelesne mase i dnevnoga prirasta junaca hranjenih TMR-obrocima

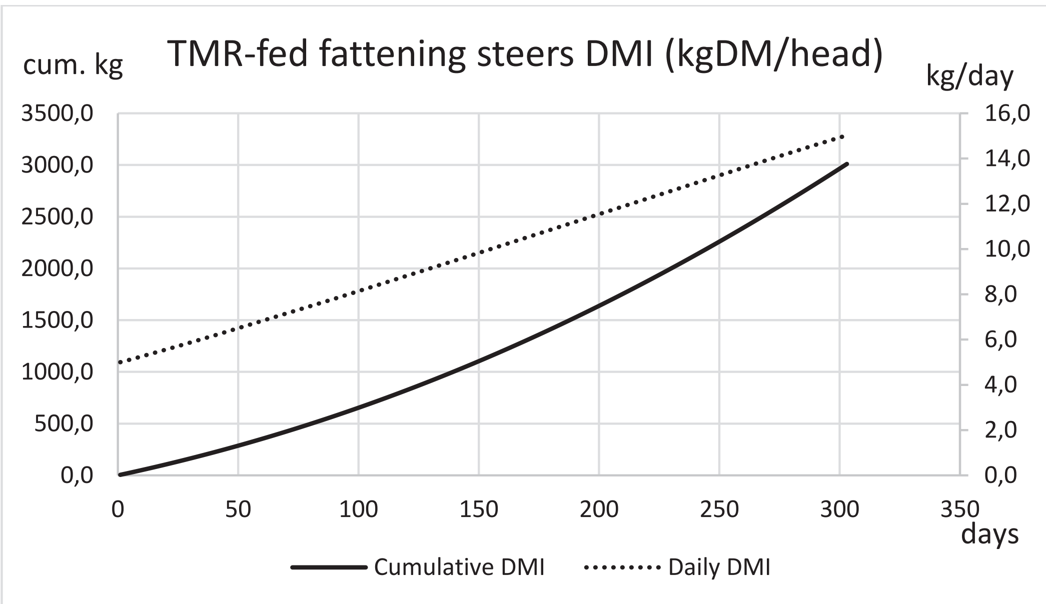

Figure 4. A projection of daily and cumulative DMI for the TMR-fed steers

Grafikon 4. Projekcija dnevne i kumulativne konzumacije suhe tvari kod junaca hranjenih TMR-obrocima

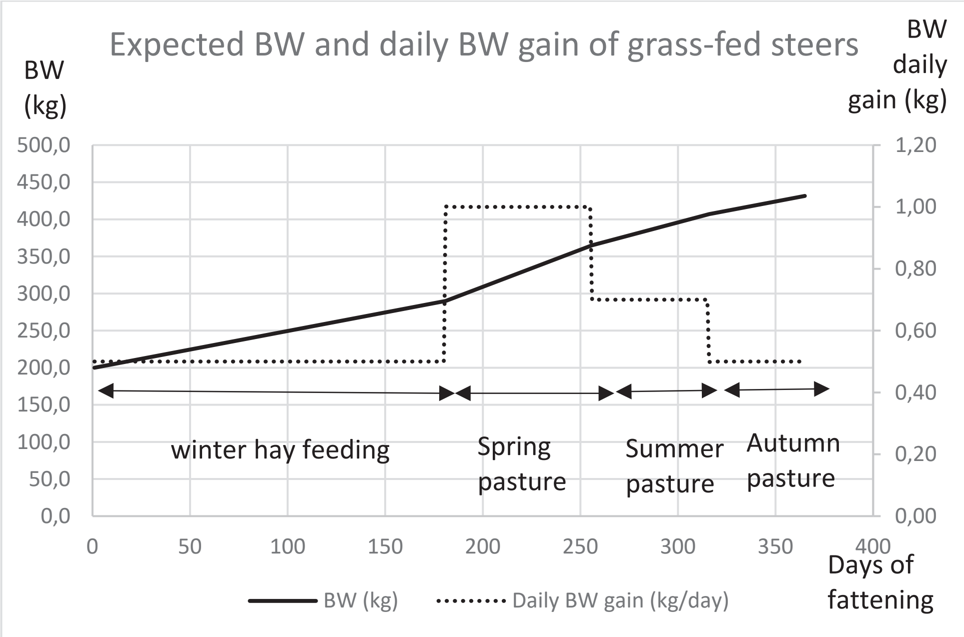

Figure 5. The assumed daily BW gain and actual BW during a year-long fattening of grass-fed steers
Grafikon 5. Projekcija dnevnog prirasta i aktualne tjelesne mase grass-fed junaca u tovu

Total BW gain of the grass-fed steers during a yearlong fattening is projected to be 231.5 kg/head, with average daily gain of 0.633 kg/head/day.

A daily DMI relative to the BW is assumed to be 2.5 % (Lalman and Richards, 2014), what has produced the curves of daily and cumulative DMI in Figure 6.

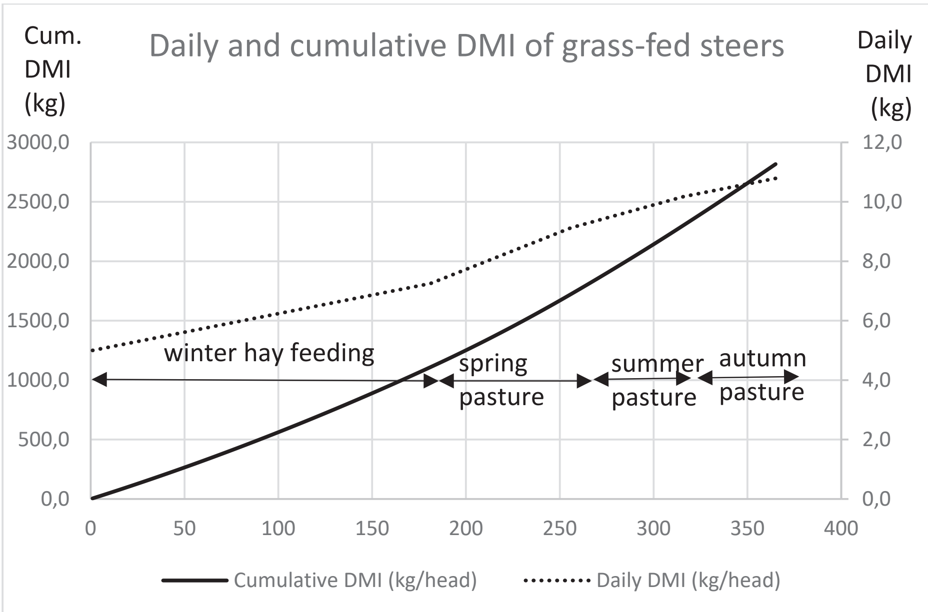

Figure 6. Projected daily and cumulative DMI of grass-fed steers
Grafikon 6. Projekcija dnevne i kumulativne konzumacije suhe tvari kod grass-fed junaca u tovu

Considering the beef cows on- and off-pasture, based on the data from Hibbard and Thrift (1992; qtd. in Lalman and Richards, 2014), below are the projected daily and cumulative DMIs (Fig. 7.). According to the AHDB (2023), an associated calf daily consumes from 0 (when several days old) to 6 kg of pasture DM per head (at weaning). Based on these data, the cumulant of the consumed DM for a calf would amount to 370 kg/head.

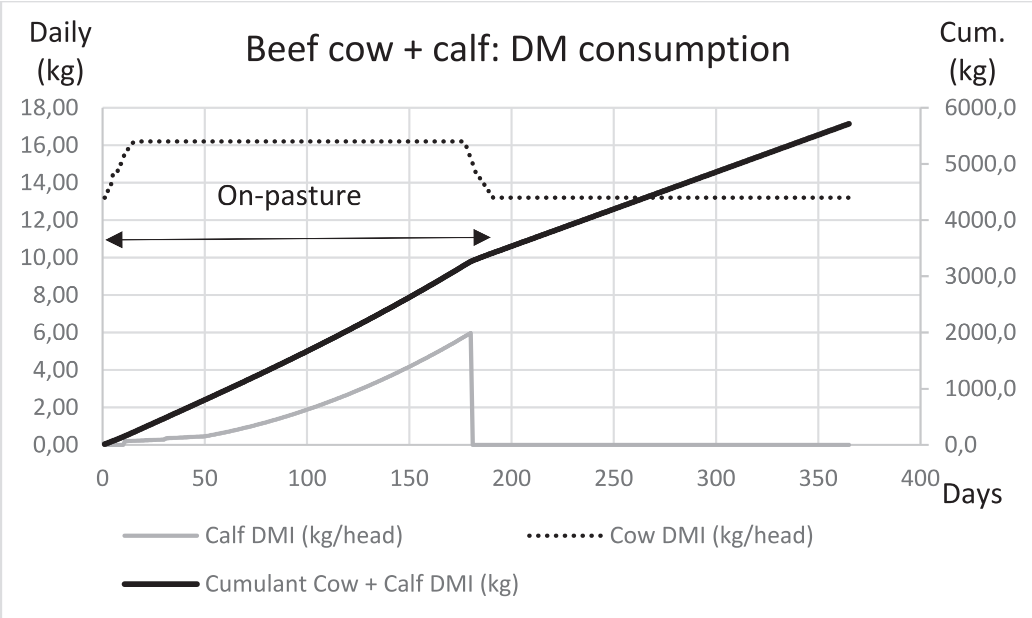

Figure 7. Daily and cumulative DMI of pasture and harvested forages by a cow-calf pair.

Grafikon 7. Projekcija dnevne i kumulativne konzumacije suhe tvari u sustavu krava-tele, grass-fed

A SUMMARY OF ANNUAL DM CONSUMPTION OF VARIOUS CATTLE PRODUCTIONS IN CONTRASTING FEEDING MANNERS

Based on the projections stated above, the TMR-fed cattle obviously perform better (Table 1), with a better feed-to-milk and feed-to-BW gain ratio (Table 2).

Table 1. Summary of the DMI projections, along with the respective productivity in the opposite feeding manners

Tablica 1. Sumarni prikaz kumulativne konzumacije suhe tvari i proizvodnosti goveda u nasuprotnim načinima hranidbe

	Feeding manner		Productivity per head	
	Annual cumulant of the consumed DM		Annual milk yield or total liveweight gain (kg/head)	
Variety of cattle production	TMR-fed	Grass-fed	TMR-fed	Grass-fed
Dairy cattle (10 months of milking + 2 months dry in winter)	7,646.5	5,447.1	10,119.0	3,800 total 1,900 saleable*
Beef cattle	3,010.2	2,817.0	400.0	231.5
Cow-calf pairs		5,714.0		200.0 (produced calf)
* half is supposed to be consumed by the grass-fed calf till the weaning (two calves per dam, Johnsen et al., 2016.).				

Table 2. A consumed feed DM-to-milk or BW gain conversion rate projected for the TMR- and the grass-fed cattle (based on the data from Table 1)

Tablica 2. Omjer konverzije konzumirane suhe tvari i proizvodnje mlijeka ili prirasta tjelesne mase (na osnovi podataka iz Tablice 1)

	Consumed feed DM to milk or BW gain conversion rate (kg/kg)	
Variety of cattle production	TMR-fed	Grass-fed
Dairy cows	0.756	1.433 (total milk) 2.866 (saleable milk)
Fattening steers	7.526	12.168
Cow-calf pairs		28.570

A poorer conversion rate in the grass-fed cattle is attributed to a lower productivity of livestock when the fed rations are lacking the energy-rich concentrates like the cereal grains. Thus, a poorer conversion rate implies that the grass-fed cattle need to consume significantly more forage DM than the TMR-fed cattle for the same milk yield or the BW gain. Also, due to the avoidance of a high-yielding, whole-crop maize diet in the grass-fed livestock, the lower yields per hectare of forage crops for feeding the grass-fed cattle are expected. Altogether, it would imply that the grass-fed cattle need considerably larger land resources to be activated for their forage production when compared with the needs of the TMR-fed cattle. However, Croatia has a relatively huge area of greatly underutilized permanent grasslands (about 1.55 million of hectares; CBS, 2003.), which might be better utilized by a broader acceptance of the grass-fed manner of cattle feeding.

According to the abovementioned projections, the grass-fed cattle rely more on the grazed forage than on the stored one (Table 3.), what is associated with the avoidance of harvesting and transportation costs for more than a half of the annually consumed forage. Also, for the grass-fed cattle, all the forage comes from the perennial forages, what is associated with many environmental benefits and potential recovery of biodiversity, as discussed above.

Table 3. A share of the grazed forage in the total annual-feed DM consumption

Tablica 3. Udio popasene krme u ukupnoj godišnjoj konzumaciji suhe tvari

Feeding manner (TMR- or grass-fed)	TMR-fed		Grass-fed		
Variety of cattle production	Pasture	Stored feeds	Pasture	Stored forage	Share of pasture (%)
Dairy cattle (10 months of milking + 2 months dry in winter)	0	7,646.5	2,825.1	2,622.0	51.9
Beef cattle	0	3,010.2	1.693.8	1,123.2	60.1
Cow-calf pairs on pasture			3,263.0	2,421	57.1

CONCLUSIONS

The presented literature review has demonstrated that, when compared to the TMR-fed cattle, the grass-fed cattle produces the cattle-derived foods with greater consumer-related health benefits, has a potential to restore biodiversity in agricultural countryside, causes a lesser environmental pollution due to a lesser pesticide use, improves the animal welfare and the beauty of a countryside landscape, decreases the farmers' operating costs, consumes less fossil fuel per hectare of utilized land which is appreciated in climate policies, and has the potential to improve the cattle farmers resilience and independence of distant fossil fuels. Grass-fed foods are appreciated by end-consumers who are willing to pay the price premium for such the products. The projected annual feed and forage consumptions along with the data on grass-fed cattle productivity have indicated the poorer conversion rate of feed to milk (1.433 vs. 0.756) and feed to bodyweight gain (12.168 vs. 7.526) in grass-fed cattle when compared to the TMR-fed, which implies that the grass-fed cattle would require much more land resources per unit of product than the TMR-fed cattle. Further research is required to test the productivity of grass-fed cattle (per head and per hectare) in Croatian conditions, as well as to investigate the productivity of Croatian grassland resources.

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GRASS-FED NAČIN HRANIDBE GOVEDA KAO OPCIJA ZA POBOLJŠANJE ODRŽIVOSTI GOVEDARSKE PROIZVODNJE U HRVATSKOJ

SAŽETAK

Uzgajivači goveda i potrošači hrane koja potječe iz govedarstva u Hrvatskoj i susjednim zemljama nisu upoznati sa značenjem pojma grass-fed goveda. Cilj je rada prikazati koje koristi za okoliš i krajnjega konzumenta može donijeti grass-fed način uzgoja goveda, kao i koja se ograničenja mogu očekivati zbog manje proizvodnosti grass-fed goveda po grlu i po jedinici proizvodnoga zemljišta. Predstavljeni pregled literature pokazao je da grass-fed način hranidbe goveda daje prehrambene proizvode s većim zdravstvenim koristima za potrošača, ima potencijal oporavljanja bioraznolikosti u agroekosustavu, uzrokuje manje zagađenje okoliša zbog manje emisije pesticida, poboljšava dobrobit životinja i ljepotu poljoprivrednoga krajolika, smanjuje troškove proizvodnje, troši manje fosilnih goriva po hektaru korištenoga poljoprivrednog zemljišta, što je poželjno sa stajališta klimatskih politika, i ima potencijal smanjiti ovisnost farmera o fosilnim gorivima. Potrošači u razvijenim ekonomijama cijene grass-fed proizvode i spremni su za njih platiti premijsku cijenu. Zajedno s podatcima o proizvodnosti grla, projicirana konzumacija suhe tvari krmiva upućuje na slabiju konverziju suhe tvari krmiva u mlijeko (1.433 vs. 0.756) i prirast tjelesne mase (12.168 vs. 7.526) kod grass-fed goveda u odnosu na goveda hranjena TMR-om, što implicira da bi grass-fed govedarstvo trebalo aktivaciju veće površine zemljišnih resursa za jedinicu govedarskih proizvoda. Potrebna su daljnja istraživanja kako bi se ispitala produktivnost grass-fed goveda (po grlu i po hektaru) u hrvatskim uvjetima, kao i da bi se istražila produktivnost hrvatskih travnjačkih resursa.

Ključne riječi: grass-fed goveda, okoliš, bioraznolikost, zdravlje potrošača, energija, emisije ugljika, klima

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