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EFFECT OF ESSENTIAL OIL SUPPLEMENT ON MILK YIELD AND COMPOSITION OF LACTATING DAIRY COWS

UTJECAJ DODATKA ESENCIJALNOG ULJA NA PROIZVODNJU MLIJEKA MLIJEČNIH KRAVA

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SUMMARY

Essential oils (EO), an important group of plant extracts, which are concentrated extracts of aromatic oily liquids from various plant materials obtained by steam distillation. Plant-derived EO is a useful means to improve efficiency of nutrient utilization in ruminants and reduce the impact of their production on the environment. In recent years, more research has been directed toward evaluating the potential of EO to improve performance in dairy cows but according to the results the effect of EO on milk production is not consistent. Therefore, the study evaluated the effects of supplementing a mixture of EO (oregano, thyme, citrus, cinnamon, ginger, curcuma, pepper and an organic carrier) in the diet of lactating Holstein Friesian dairy cows (n=46) in late lactation on the intake, milk yield and composition in a dairy farm experiment. The average DIM at the start of the experiment was 156 days. Experimental treatments consisted of a mixture of EO (2 g cow^{-1} day^{-1}) inclusion in a total mixed ration. There was a 3-week long preliminary and a 7-week long experimental period in the trial. Milk production was recorded every day. Chemical analyses were made from the morning milked samples once a week. Supplementation of dairy cows with mixture of EO significantly ($P<0.05$) increased the dry matter intake (control: 26.9±1.49 kg DM day^{-1} vs. experimental: 27.3±0.95 kg DM day^{-1}) but had no effect on milk production (control: 38.3±4.99 kg *vs*. experimental: 37.9±4.93 kg) and milk composition (fat, protein, lactose). Results show that an intake of 2 g cow^{-1} day^{-1} mixture of EO may increase the feed intake but does not influence milk yield and composition in late lactation.

Key words: dairy, essential oil, feed intake, milk production, milk composition

INTRODUCTION

Feed additives are typically non-nutritive compounds added to ruminant diets to help animals utilize nutrients better. In the last few decades various chemical feed additives like ionophores, antibiotics, and methane inhibitors have been evaluated in ruminant diets to regulate rumen fermentation, increase growth and milk yield, and also increase feed intake and efficiency. Increased awareness from public health aspects like chemical residues in milk and meat and bacterial resistance to antibiotics resulting from increased use of these additives led to prohibited use of some of these additives. Therefore consumers demand for safe, high quality nutritious food has stimulated the search for natural alternative additives such as probiotics, yeast products, enzymes and essential oils.

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Essential oils (EO) are concentrated extracts of aromatic oily liquids from various plant materials (e.g. leaves, flowers, stem, seeds, roots, bark, pulp, fruit) obtained by steam distillation or solvent extraction. Chemically, EO are complex mixtures of mono- and sesquiterpenes and biogenically related phenolics or monophenols (Hummelbrunner and Isman, 2001.). The well documented antimicrobial activity of essential oils (EO) and their active components, has prompted a number of scientists to examine the potential of these secondary metabolites to manipulate rumen microbial fermentation to improve nutrient utilisation in ruminants. Therefore in recent decade, more research has been directed toward evaluating the potential of EO to improve performance in dairy cows as well (Yang et al., 2007.; Benchaar et al., 2008.; Agarwal et al., 2009.; Santos et al., 2010.; Tager and Krause, 2011.) and to understand effects on the ruminal fermentation (Molero et al., 2004.; Newbold et al., 2004.; Castillejos et al., 2007.). The main effects of EO in the rumen have been suggested to be due to the reduction of protein and starch degradation, an inhibition of amino acid degradation due to selective action on certain rumen micro-organism (Hart et al., 2008.). EO have also shown some promise in inhibiting the methanogenic archaea and methane production. Supplementation with EO or their components has caused either a decrease or no change in total VFA concentration in most studies, therefore microbial populations are able to adapt to EO over time (Benchaar et al., 2008.).

Many studies have been published on effects of EO on milk production and composition of dairy cows. The effect of EO on milk production is not consistent. Supplementation of EO to dairy cows in early lactation has resulted in increased milk yield (Kung et al., 2008.) or no effect on milk yield and milk composition (Hosoda et al., 2005.). Santos et al. (2010.) observed an increased milk fat percentage, but no effect on milk production or on other milk components when feeding of EO mixture (eugenol, geranyl acetate and coriander oil). Although, the yields of milk and milk fat were not changed by feeding of EO in the study of Tassoul and Shaver (2009.), efficiency of milk production increased due to addition of EO in the diet of dairy cattle. Most of the investigations conducted to date on EO have been done in early lactation, therefore, the objective of this study was to determine the effect of EO on feed intake, milk composition in late lactating dairy cows.

MATERIAL AND METHODS

Animals and management

The experiment was conducted at a commercial dairy farm situated in the western part of Hungary. In a randomized complete block design forty-six multiparous Holstein–Friesian cows were paired by live weight (673±24 kg), lactation number, days in milk, milk production during the previous lactation (23,210.65 vs 23,123.83 kg). The cows were in the second and third lactation and the average DIM at the start of the experiment was 156 days. Within pairs they were randomly allocated to two treatments: a control and experimental (EO fed). The diet consisted of a total mixed ration (TMR) based on corn silage, alfalfa haylage, Italian ryegrass silage and dairy concentrate (Table 1). Starch content of the diet was in correspondence with Hungarian farm practice (25% of starch in DM). A specific blend of EO compounds (essential oils of oregano, thyme, citrus, cinnamon, spices like ginger, curcuma, pepper and an organic carrier) was given to the cows in the experimental group (EO treatment) daily. The EO compounds for the ration (2 g/cow/day) were mixed with wheat flour and then blended into the concentrate grain mix during formulation at the feed mill. During this trial all cows were fed *ad libitum* twice daily at 1100 and 1700 h. Water and mineral salt were freely available. Feed intake was measured by weighing TMR offered at each feeding and removing and weighing orts the next morning.

Cows were milked three times daily (morning, noon, evening) and milk production was recorded automatically via computer. Individual milk samples were taken weekly throughout the trial at consecutive afternoon and morning milking. Experimental periods were 7 weeks. Milk production and milk composition were evaluated after a 3 weeks adaptation period to the experimental diets.

Chemical analysis and calculations

The composition of milk was analysed by the Hungarian Dairy Research Institute (Mosonmagyaróvár, Hungary), where the fat, protein, lactose and dry matter contents of the milk were measured. Milkoscan FT 120 (Foss Electric) equipment was used for the analysis. Silage and TMR samples were collected three times a week and stored at -20 °C. At the end of each week, frozen samples were thawed and composited. Samples of each concentrate mix and hay were collected once a week. Dry matter of all weekly samples was determined following drying for 48 h in a forced-air oven at 60°C, and used for weekly DM adjustments of TMR mixing. The chemical content of the feeds (DM, CP, CF, EE, starch, sugar, ash) was analysed according to the Hungarian Feed Codex (2004). Starch content of feed was measured with a polarimeter (Carl Zeiss, Jena, Germany) as described in the Hungarian Feed Codex (2004.).

Table 1 Ration composition and analysed ration nutrient composition

Tablica 1. Sirovinski i kemijski sastav obroka

Item	Control	Experimental
Ingredient composition, kg day^{-1}		
Corn silage	14.0	14.0
Alfalfa haylage	8.0	8.0
Italian ryegrass silage	5.0	5.0
Wet corn	2.7	2.7
Alfalfa hay	2.0	2.0
ProteMix[2]	0.5	0.5
Dairy concentrate*[1]	11.6	11.6
EO Mix[3]	0.0	0.002
Chemical composition, g/kg of DM		
Crude protein	167.6	175.0
Crude fibre	174.1	177.7
Ether extract	37.5	35.3
Nitrogen free extract**	544.1	535.1
Starch	251.5	240.0
Sugar	41.5	43.0
Ash	76.6	77.0

* rapeseed meal (2.47 kg day^{-1}), ReProt energy (1.16 kg day^{-1}), wheat flour (2.76 kg day^{-1}), molasses (0.12 kg day), sodium bicarbonate (0.07 kg day^{-1}), lime (0.12 kg day^{-1}), corn (2.9 kg day^{-1}), HUB 8390 premix (0.6 kg day^{-1}). Contents per kg of premix: 120 g Ca, 66.7 g of P, 106.4 g of Na, 40 g of Mg, 1.000.000 IU of vitamin A, 200.000 IU of vitamin D-3, 5.000 mg of vitamin E, 1.000 mg of Copper-sulphate pentahydrate, 500 mg organic Copper, 3.800 mg of Zinc-sulphate, 5.000 mg of organic Zinc, 3.000 mg of organic Manganese, 5.000 mg of Manganese-sulphate, 100 mg of Calcium-iodate anhydrate, 20 mg of Sodium-selenite, 20 mg of organic Selenite, 90 mg of Cobalt-carbonate hydrate, 10 mg of Citric acid, 16 mg of Etoxiquin, 108 mg of BHT, 10 mg of BHA), SoyPreme (1.6 kg day^{-1}), Immuno Wall (0.06 kg day^{-1}).

** calculated

[1] UBM Feed Kft. (Pilisvörösvár, Hungary);

[2] Hungarian AgriFeed Kft. (Mosonmagyaróvár, Hungary);

[3] Adexgo Kft. (Balatonfüred, Hungary).

Calculations: Fat-corrected milk was calculated as FCM (kg/d)=0.4×milk, kg/d + 15×fat, kg/d. Energy-corrected milk was calculated as ECM (kg/d)=milk production kg × (383 × fat% + 242 × protein% + 165 × lactose% + 20.7)/ 3.140

Statistical analysis

Evaluation of data was performed by one-factor variant analysis (Kolmogorov-Smirnov test, t-test, Kruskal-Wallis test, Mann-Whitney test) with SPSS 19.0 Windows Program (SPSS Inc., Chicago, USA). Statistical significance was considered at $P<0.05$.

RESULTS AND DISCUSSION

The effect of supplementation of dairy cows with EO on DMI, milk production and composition variables are summarised in Table 2. Dry matter intake is highly important to evaluate the quality of the diets fed to lactating cows, and the results of this experiment showed that feeding up to 2 g day^{-1} of EO dry matter intake was increased ($P<0.05$) in EO cows relative to control cows. In agreement with our findings Tekippe et al. (2013.) and Reza-Yazdi et al. (2014.) conclude that a blend of eugenol (28%) and cinnamaldehyde (17%) can increase DMI in lactating dairy cows. Rayana et al. (2015.) summarized that feeding a mixture of carvacrol, cinamaldehyde, eugenol, and capsaicin decreased DMI of dairy cows in late lactation (181 ± 102 DIM). Benchaar et al. (2006.) used a product containing a mixture of EO at a 2 g cow day^{-1} in the diet of lactating cows and found no effect on DM and nutrient intake. Little information is available on the effect of EO on feed intake in dairy cows. A possible explanation for the higher DMI with EO supplementation could be that EO in late lactation cows positively influenced the palatability of the TMR fed in this study. The TMR in late lactations contains more forage, than the diet in early lactation, and if the qualities of the fibrous ingredients are low, the EO supplementation will help to keep high the DMI. In contrast with our results Tassoul and Shaver (2009.) reported a reduction of 7% in dry matter intake during the first 15 weeks of lactation in cows with higher milk yield (48 kg day^{-1}), when using EO supplementation. The authors suggested that a possible explanation for the decreased dry matter intake could be that EO adversely influenced the palatability of the TMR fed in the assay. Various responses to EO supplements on DMI of dairy cows may be attributed to differences in dose, duration and processing of the medical plants. It is unclear how EO modulates feed intake, but the effect might be partly attributed to the apparent improvement in ruminal function and increased fibre digestibility (Wall et al., 2014.).

There were no differences (P>0.05) between treatments with regard to milk yield, and 4% fat-corrected milk yield and ECM. Milk composition was not affected either (P>0.05) by the inclusion of EO in to the diet (Table 2) and the average concentration of protein and fat were 3.5% and 3.09%, respectively. The daily production of milk protein and milk fat were not affected (P>0.05) by EO inclusion indicating that it might be the absorbed component(s) of EO that has a pharmacological activity which does not affect the syntheses of milk and its components. These results were supported by various other studies. EO supplementation had no effect on milk protein and milk fat concentration (Benchaar et al., 2006. and Benchaar et al., 2007.). Santos et al (2010.) and Rayana et al. (2015.), however, found that milk fat production and milk fat proportion were higher in cows supplemented with EO.

Table 2 Effect of EO addition on dry matter intake, feed intake, milk production and composition

Tablica 2. Učinak dodatka esencijalnih ulja na konzumaciju suhe tvari, unos hrane te proizvodnju i sastav mlijeka mlijeka

Item	Control	Experimental
Dry matter intake, kg day^{-1}	26.9±1.49^{a}	27.3±0.95^{b}
Milk yield, kg/d	38.3±4.99	37.9±4.93
4% FCM yield, kg/d	34.9	35.2
ECM, kg/d	35.3	35.5
Milk fat, %	3.46±0.63	3.53±0.74
Milk fat, g/d	1325	1388
Milk protein, %	3.09±0.20	3.09±0.16
Milk protein, g/d	1180	1171
Milk lactose, %	5.03±0.35	4.97±0.16
Milk lactose, g/d	1926	1884
DM, %	2.22±0.70	12.25±0.75

[a,b] figures with different superscript in the same row differ significantly (P<0.05)

CONCLUSION

Addition of a specific mixture of EO compounds had significant effects on dry matter intake in dairy cows in late lactation, but no effect on milk production and composition, therefore further studies should evaluate the effects of these EO on milk production.

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SAŽETAK

Esencijalna ulja (EO), važna skupina iz biljnih ekstrakata, kooncentrirani su ekstrakti aromatičnih uljnih tekućina iz različitih biljnih materijala dobivenih parnom destilacijom. Biljno esencijalno ulje je korisno sredstvo za poboljšanje djelotvornosti iskorištavanja hranjivih tvari preživača i smanjenje djelovanja njegove proizvodnje na okoliš. Zadnjih godina više je istraživanja usmjereno na procjenu potencijala esencijalnih ulja za poboljšanje djelotvornosti mliječnih krava ali prema rezultatima djelovanja esencijalnih ulja na proizvodnju mlijeka nije dosljedno. Stoga se u radu procjenjuje djelovanje dodavanja mješavine esencijalnih ulja (origano, majčina dušica, limun, cimet, đumbir, papar i organski nosač) u obroke Holštajn i Frizijskih mliječnih krava u kasnoj laktaciji (n=46) na unos hrane, prinos i sastav mlijeka u pokusu na mliječnoj farmi. Prosječan DIM na početku pokusa bio je 156 dana. Pokusni tretmani sastojali su se od dodavanja smjese esencijalnih ulja (2g/dan) u ukupnu smjesu obroka. Pokus se sastojao od 3 tjedna pripremnog i 7 tjedana pokusnog razdoblja. Proizvodnja mlijeka bilježila se svakog dana. Kemijske analize obavljene su iz jutrom pomuzenog mlijeka jednom tjedno. Dodavanje mliječnim kravama smjese aromatičnih ulja značajno ($P<0{,}05$) je povećalo unos suhe tvari (kontrola: 26,9+1,49 kg DM dnevno prema pokus: 27,3 +0,95 kg DM dnevno), ali nije djelovalo na proizvodnju mlijeka (kontrola: 38,3+4,99 kg prema pokus.37,9+4,93 kg) i sastav mlijeka (masnoća, bjelančevina, laktoza). Rezultati pokazuju da dnevni unos po kravi 2 g smjese aromatičnih ulja može povećati unos hrane, ali ne utječe na prinos i sastav mlijeka u kasnoj laktaciji.

Ključne riječi: mliječni, esencijalno ulje, unos hrane, proizvodnja mlijeka, sastav mlijeka