ESSENTIAL OILS AS DIETARY SUPPLEMENTS FOR DAIRY COWS[1]

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Newbold et al. (2006) and Calsamiglia et al. (2007) described essential oils (EO) as follows: volatile aromatic compounds with an oily appearance extracted from plant materials typically by steam distillation; alcohol, ester or aldehyde derivatives of phenylproponoids and terpenoids; some of the more common EO compounds available include thymol (thyme and oregano), eugenol (clove), pinene (Juniper), limonene (dill), cinnamaldehyde (cinnamon), capsaicin (hot peppers), terpinene (tea tree), allicin (garlic), anethol (anise), etc.; antimicrobial activity; modify rumen microbial fermentation. With regard to EO as modifiers of rumen microbial fermentation, Calsamiglia et al. (2007) from an extensive review of the literature (primarily in vitro, in situ or continuous culture based) concluded the following: inhibition of deamination and methanogenesis, which results in lower ammonia-N, methane and acetate and higher propionate and butyrate concentrations; effects may vary depending on the specific EO or combination of EO supplemented; effects of some EO are pH and diet dependent. Readers are referred to Calsamiglia et al. (2007) for an in depth review of EO and effects on rumen microbial fermentation. The purpose of this paper is to review the available research reports involving EO as dietary supplements for dairy cows.

ESSENTIAL OILS AND LACTATION PERFORMANCE BY DAIRY COWS

Seven reports on the effects of EO supplemented in diets fed to lactating dairy cows were reviewed and summarized by Tassoul and Shaver (2008a). Six of these reports involved the CRINA ruminants (CRINA S.A., Gland, Switzerland) mixture of natural and synthesized EO including thymol, eugenol, vanillin, guaiacol, and limonene. The other report involved EO (Axiss France SAS, Bellegarde-sur-Valserine, France) from garlic (allicin) and juniper berry (pinene) fed separately. EO numerically increased DMI and feed efficiency in 6/9 treatment comparisons. Milk yield and composition (fat and protein percentages) were increased numerically by EO in 8/10 and 6/10 treatment comparisons, respectively. DMI, milk yield and milk fat percentage increases were significant ($P < 0.10$) in 1/9, 4/10 and 3/10 treatment comparisons. Other responses ($P < 0.10$) reported were increased ruminal OM and N digestibility (Yang et al., 2007), increased ruminal pH and reduced total VFA (Benchaar et al., 2007), and increased total tract ADF digestibility and ruminal pH (Benchaar et al., 2006).

In a recent UW-Madison trial (Tassoul and Shaver, 2008b), our objective was to evaluate transition cow and 15-wk postpartum lactation performance responses to dietary EO supplementation. Forty multiparous Holstein cows were used in a completely randomized design. Treatments were a control diet supplemented with a placebo premix (57 g/cow/d) and an EO diet supplemented with 1.2 g/cow/d CRINA Ruminants (CRINA S.A., Gland, Switzerland; mixture of natural and synthesized EO including thymol, eugenol, vanillin, guaiacol, and limonene) provided through a premix (57 g/cow/d). Treatment diets were fed from 4 wk prepartum through 15 wk of lactation. Prepartum and lactation TMR ingredient and nutrient composition are presented in Table 1. Cows were fed individually a TMR once daily in tie-stalls and the amounts fed and refused were recorded daily. Body weights and condition scores will were recorded weekly throughout the trial. Blood samples from each cow obtained prior to feeding on d -21, -7, -1, 1, 8, 15, 22, and 29 were analyzed for glucose, BHBA, NEFA, and urea-N. Milk yield was recorded daily on individual cows from throughout the lactation trial. Milk samples obtained from all cows weekly on two consecutive days of the week from am and pm harvests throughout the lactation trial were analyzed for fat, true protein, lactose and MUN concentrations. Results are presented in Table 2 and Figures 1-3. There was no affect of EO on prepartum DMI. Lactation DMI was 1.8

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kg/cow/d lower for EO (P < 0.04). Milk and component yields were unaffected by treatment. Milk true protein was 0.15%-units lower for EO (P <0.03). Milk yield was numerically lower for EO during lactation wk 1-5 (-2.4 kg/cow/d), similar during wk 6-10, and numerically higher (+2.1 kg/cow/d) for EO during wk 11-15 (Figure 1). Unfortunately, the feeding trial was not continued any further into the lactation. Average feed efficiencies (Milk/DMI and FCM/DMI) tended to be greater for EO (P < 0.08 and P < 0.07, respectively). Feed efficiency (Milk/DMI) was unaffected by treatment during lactation wk 1-5, but was greater for EO during wk 6-10 and wk 11-15 (P < 0.04 and P < 0.02, respectively; Figure 2). Average lactation energy balance tended to be lower for EO (P < 0.06). Energy balance was unaffected by treatment during lactation wk 1-5, but was lower for EO during wk 6-10 and wk 11-15 (P < 0.04 and P < 0.03, respectively; Figure 3). Control cows returned to positive energy balance during lactation wk 6-10 (+1.5 Mcal/d), while EO cows remained in slightly negative energy balance even during wk 11-15 (-0.4 Mcal/d; Figure 3). Prepartum and lactation body weight, body condition score, and blood sample measurements were unaffected by treatment.

Tassoul and Shaver (2008a) analyzed combined data from the literature review and the UW-Madison trial using the MIXED procedure of SAS to evaluate animal response to dietary EO supplementation for DMI and milk, fat and protein yields. The model included the fixed effect of EO supplementation and the random effect of trial (St. Pierre, 2001). Each response was weighted according to the number of animals used to test for it using the WEIGHT statement. DMI was unaffected by treatment (P > 0.10). Milk, fat and protein yields were 1.2 (P < 0.04), 0.06 (P < 0.03) and 0.05 (P < 0.06) kg/d, respectively, higher for EO.

Bravo and Doane (2008) recently presented results from a meta-analysis of lactating dairy cow trials involving EO comprised of cinnamaldehyde and eugenol (Pancosma, Geneva, Switzerland); 16 trials and 33 treatment comparisons. EO increased DMI and milk yield by 1.5 kg/d (P < 0.001) and 1.1 kg/d (P <0.001), respectively. It was reported that diet nutrient composition, greater NEL, NFC or NDFD, improved the milk yield response to EO (Bravo and Doane, 2008).

CONCLUSIONS

Effects of EO on rumen microbial fermentation in vitro or in situ are well established (Calsamiglia et al., 2007). This review shows efficacy of EO on lactation performance by dairy cows. However, more dairy cattle research regarding potential interactions between basal diet, stage of lactation and dietary EO supplementation, specifically dose and EO composition, is needed before EO can be used with confidence in commercial practice. Also, further research on the role of EO versus other anti-microbials, i.e. monensin sodium, is warranted.

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Table 1. UW-Madison trial diet ingredient and nutrient composition (Tassoul and Shaver, 2008b).

	Prefresh TMR	**Lactation TMR**
Ingredients, % DM		
Alfalfa silage	11.0	17.0
Corn silage	48.0	30.0
Mixed Alfalfa/Grass Hay	--	3.7
Wheat straw	11.0	--
Ground shelled corn	18.2	22.0
Soybean meal-48%	9.2	9.2
Distillers dried grains	--	9.2
Whole cottonseed-linted	--	5.6
Tallow	--	0.9
Minerals & Vitamins	2.6	2.4
Nutrients[1]		
DM, % as fed	46.1 ± 2.9	53.6 ± 3.0
	--------------------DM basis--------------------	
CP %	12.5 ± 0.7	17.1 ± 0.8
NDF%	38.1 ± 4.6	35.3 ± 1.9
Starch%	29.9 ± 4.6	24.7 ± 2.1
Fat%	3.5 ± 0.4	6.0 ± 0.2
TDN_{1x}%	68.9 ± 1.9	--
NEL_{3x}, Mcal/kg	--	1.71 ± 0.03

[1]TMR sampled weekly, composited by month, and analyzed using wet chemistry by Dairy One (Ithaca, NY).

Table 2. UW-Madison trial results (Tassoul and Shaver, 2008b).

	Control	**Crina**	**SEM**	**P<**
Prepartum DMI, kg/d	13.8	13.1	0.4	NS[1]
Lactation DMI, kg/d	24.5	22.7	0.6	0.04
Milk Yield, kg/d	48.2	48.1	1.1	NS
4% FCM, kg/d	43.9	44.0	1.2	NS
Fat				
%	3.48	3.46	0.10	NS
kg/d	1.65	1.64	0.09	NS
True Protein				
%	3.10	2.95	0.05	0.03
kg/d	1.46	1.41	0.06	NS
MUN, mg%	12.9	13.4	0.3	NS
Milk/DMI	1.99	2.15	0.06	0.08
FCM/DMI	1.83	1.98	0.06	0.07
Lactation EB[2], Mcal/d	-1.1	-3.6	0.9	0.06
Body Condition Score				
Prepartum	3.9	3.8	0.1	NS
Lactation	3.4	3.3	0.1	NS
Body Weight, kg				
Prepartum	734.2	745.3	16.0	NS
Lactation	672.0	657.7	15.5	NS
Blood Data[3]				
NEFA, mEq/L	524.1	530.9	34.5	NS
BHBA, mg/dL	6.9	7.8	0.6	NS
Glucose, mg/dL	53.8	55.0	0.9	NS
Urea-N, mg/dL	11.9	12.0	0.3	NS

[1]Not significant (P > 0.10).
[2]Energy balance = $((DMI*NEL_{Diet}) - ((0.08*BW^{0.75})+(NEL_{Milk}*Milk)))$.
[3]Averaged across -21, -7, -1, 1, 8, 15, 22, and 29 d samples.

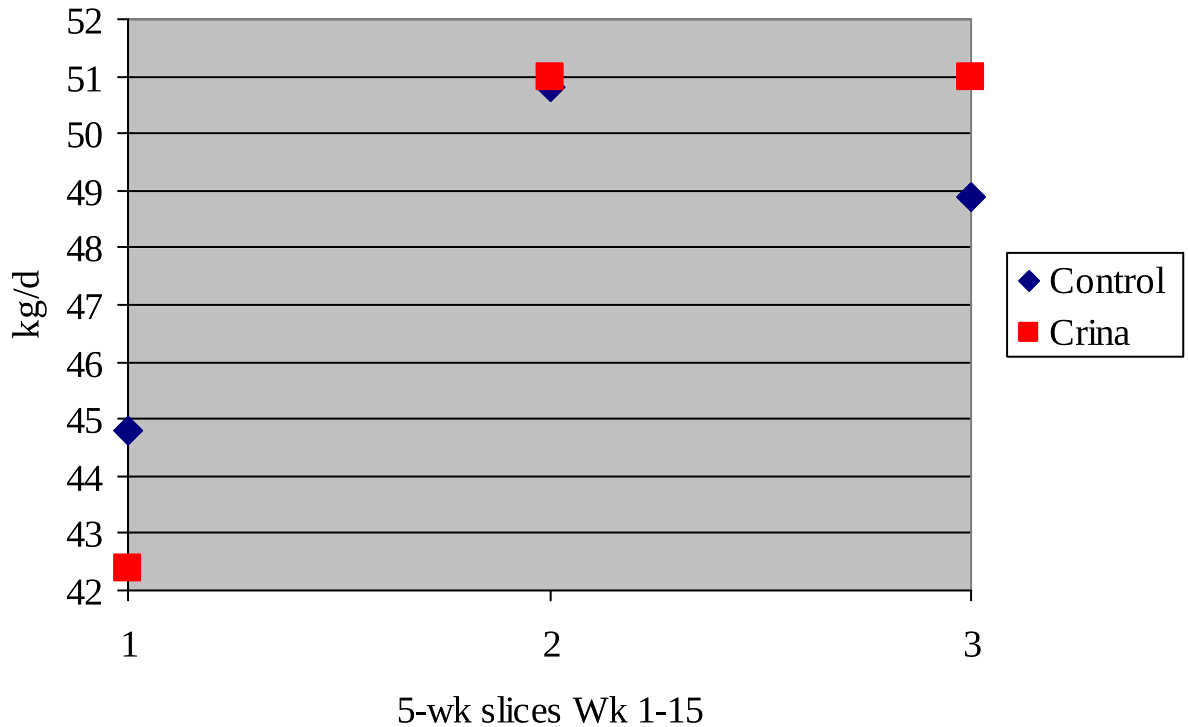

Figure 1. Milk yield (kg/d) summarized by 5-wk slices from wk 1-15 of lactation (P >0.10 differences and SEM = 1.3 kg/d for each slice; Tassoul and Shaver, 2008b).

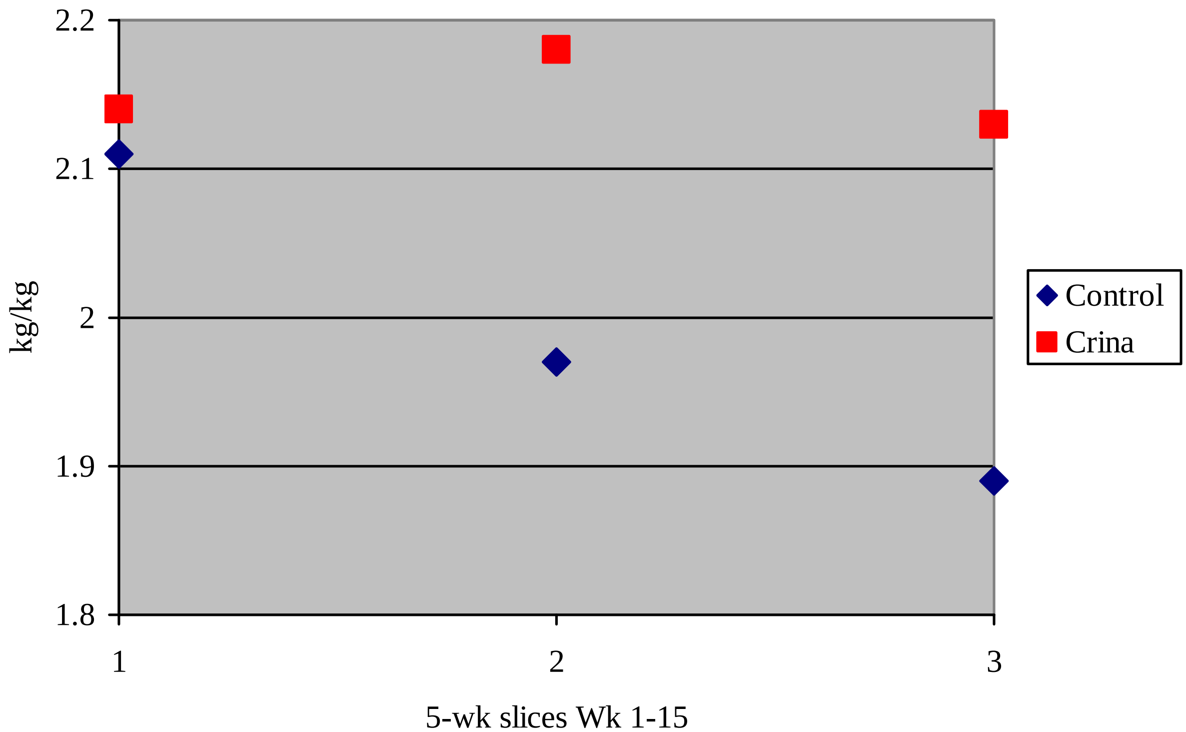

Figure 2. Feed efficiency (kg Milk/ kg DMI) summarized by 5-wk slices from wk 1-15 of lactation (Slice 1 - $P > 0.10$; Slice 2 - $P < 0.04$; Slice 3 - $P < 0.02$; SEM = 0.07 by slice; Tassoul and Shaver, 2008b).

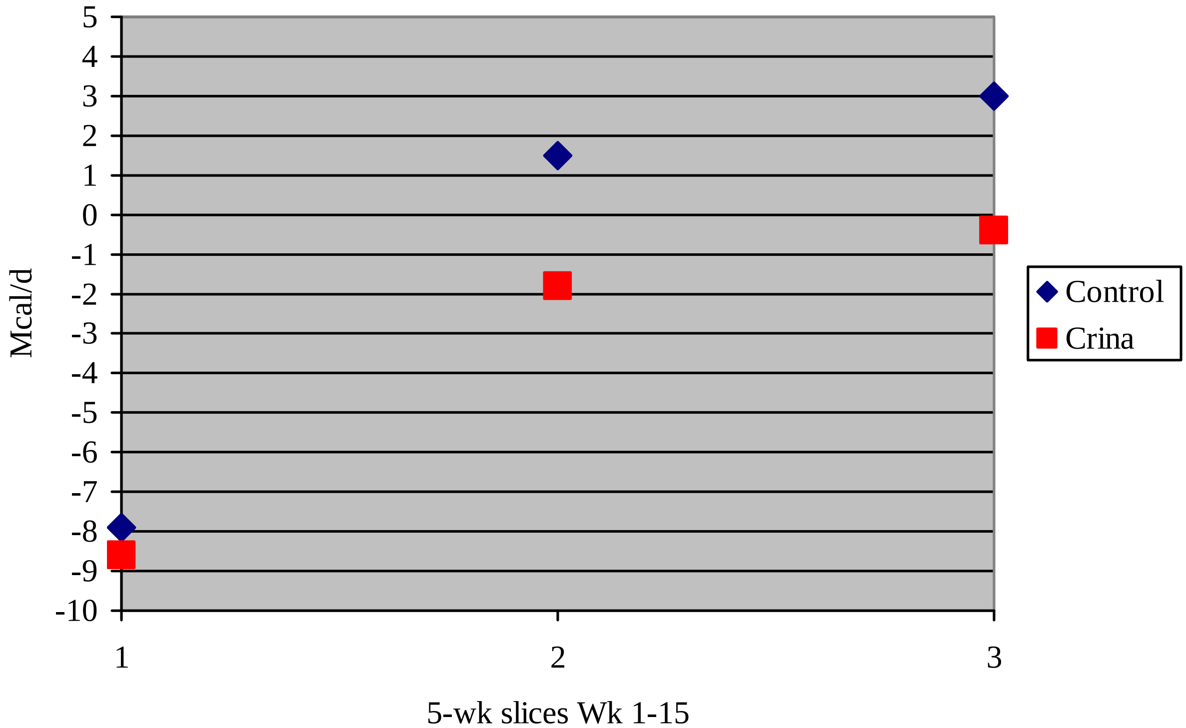

Figure 3. Energy balance (Mcal/d) summarized by 5-wk slices from wk 1-15 of lactation (Slice 1 - P > 0.10; Slice 2 - P < 0.04; Slice 3 - P < 0.03; SEM = 1.1Mcal/d by slice; Tassoul and Shaver, 2008b).