The use of essential oils in animal nutrition

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SUMMARY – The potential of essential oils (EO) in animal nutrition is discussed with some selected examples obtained with the blends produced by CRINA SA. Synergistic effects of EO on endogenous enzyme production and on microbial flora are used to increase animal performances. In ruminants, blends can be created that significantly reduce rumen ammonia production and increase protein by-pass. In monogastrics, the effect on the colonisation of the guts by different bacteria (*Clostridium perfringens* in poultry and haemolytic *E. coli* in pigs) will be shown. The effects on feed efficiency and daily weight gain in pigs are shown as a model for the expected effects on animal performances.

Key words: Essential oils, pigs, poultry, ruminants.

RESUME – *"Utilisation d'huiles essentielles en nutrition animale". Le potentiel des huiles essentielles en nutrition animale est discuté à travers quelques exemples choisis obtenus avec les mélanges produits par CRINA S.A. Les effets de synergie des huiles essentielles sur la production d'enzymes endogènes et sur la flore microbienne sont utilisés pour augmenter les performances des animaux. Chez les ruminants, on peut créer des mélanges qui réduisent de manière significative la production d'ammoniac dans le rumen et augmentent le by-pass des protéines. Chez les monogastriques, on montrera l'effet sur la colonisation de l'intestin par différentes bactéries (*Clostridium perfringens *chez les volailles et* E. coli *hémolytique chez les porcins). Les effets de l'efficacité alimentaire et du gain de poids quotidien chez les porcins sont montrés comme modèle des effets espérés sur les performances animales.*

Mots-clés : *Huiles essentielles, porcins, volailles, ruminants.*

Essential oils (EO) are volatile oils obtained from plants or from part thereof by, for example, steam and/or water distillation. Most essential oils consist of mixtures of hydrocarbons (terpenes, sesquiterpenes, etc.), oxygenated compounds (alcohol, esters, aldehydes, ketones, etc.) and a small percentage of non-volatile residues (paraffin, wax, etc.). These active ingredients can also be produced in nature-identical form with an identical chemical structure as those present in naturally occurring raw materials and their extracts. To comply with food legislation these have a degree of purity of at least 99.5%.

The effects of EO's is widely known in human and in animal use. From all the properties and the possible synergistic effects we will discuss just two in this paper: the stimulation of endogenous enzymes and the regulation of the gut microbial flora and its help in maintaining the health of the animals.

The stimulation, by hot spices, of endogenous enzymes is a well known effect (e.g. Blumberger and Glatzel, 1963) with the basic mechanisms recently elucidated (Caterina *et al.*, 1997).

The effects of EO on micro-organisms are also known (e.g. Pruthi, 1980) and the basic mechanisms for some of them were reported (Helander *et al.*, 1998).

Many reports on the synergistic effects between EO (Geda, 1995), but also between EO and other feed additives (e.g. NaCl, Kurita and Koike, 1982) or even diets, can be found in the literature.

It is the use of the synergistic effects between the different essential oil components that is the basis of all the blends produced by CRINA SA. Some selected results in the use of these EO blends will be presented here, to give an impression about the potential of their application in animal nutrition.

One of the first consequences when changing the production of endogenous enzymes is a change in the gut substrate. As shown by Francesch *et al.* (1999) one method of measuring this effect is by

analysing digesta viscosity. In a trial with broilers, on a diet based on wheat and barley, it could be shown that the inclusion of CRINA for POULTRY, not only improved feed efficiency by 5% from 1 to 40 days of age, but also had a positive significant effect on reducing digesta viscosity and percentage of birds with sticky droppings ($p < 0.05$) (Table 1).

Table 1. Ileal digesta viscosity and sticky
droppings

Control	Virginiamycin	Enzyme	CRINA
Ileal digesta viscosity (cPs)			
9.0	9.3	3.0	6.0
Sticky droppings (%)			
50	55	19	21

The effects of EO in the regulation of the microbial flora could be confirmed in a set of trials. For example, as shown by Newbold et al. (1999), there is a remarkable effect on the ammonia production by rumen fluid in vitro. Four Holstein-Fresian cows, each fitted with permanent rumen cannula, were offered ad libitum access to a TMR of grass and maize silage plus a concentrate mix (33,22 and 45 g/100 g on a DM basis). Animals received the diet plus or minus 1 g/d of CRINA for RUMINANTS as part of a 2 x 2 design with 4 weeks periods (Table 2).

Table 2. Effect of feeding EO to cattle on the subsequent production
of ammonia from casein acid hydrolysate and Trypticase in
the presence and absence of monensin rumen fluid in vitro

	Control	EO	SED
Ammonia production from casein acid hydrolysate (nmolNH3 produced/mg protein/h)			
No monensin	410	372	9.8*
5 µM monensin	280	287	10.9
Ammonia production from Trypticase (nmolNH3 produced/mg protein/h)			
No monensin	434	384	4.6*
5 µM monensin	306	294	7.0

EO inhibited ($p < 0.05$) the production of ammonia from both casein hydrolysate and trypticase. Moreover, in the present experiment, a well know group of bacteria, present in low numbers but with very high rates of ammonia production, and responsible for 30% of ammonia production in control animals, were found to be sensitive to the EO. It is therefore reasonable to conclude that EO inhibited ammonia production in rumen fluid by inhibiting the activity of these bacteria.

As shown in another trial with a similar design (Newbold et al., 2000) CRINA for RUMINANTS inhibited the ruminal degradation of soyabean meal N from dragon bags incubated in situ. Once more the deamination of amino acids measured in vitro in rumen fluid removed from the animals decreased by 25% ($p < 0.05$). However EO did not have a major influence on other aspects of rumen fermentation.

The effects of EO on animal microbial flora can also be obtained in the intestine of monogastric animals and not only in the rumen. The next trials will show these effects.

The first experiment (Cadogan et al., 1998) was conducted to investigate the responses of pigs weaned at 23 days to CRINA for PIGLETS. 2 x 12 male and 2 x 12 female piglets were offered a

wheat, lupin, soya diet (CP 24%, DE 14.7 MJ/kg), with or without 100 p.p.m. of CRINA for PIGLETS. 5 days after weaning the excrements were collected and analysed for hemolytic *E. coli*, as an indicator of changes in the microbial flora (Table 3).

Table 3. The effect of CRINA for PIGLETS on hemolytic *E. coli* excretion rate as % of total *E. coli* excretion

	Control	CRINA
Male	0.15	0.07
Female	0.06	0.01

The addition of CRINA for PIGLETS reduced the hemolytic excretion rate by almost 50% in males and from 6 to only 1% in females. These results suggest that CRINA for PIGLETS inhibits the proliferation of *E. coli* in the newly weaned pig and may have a prophylactic role to play.

The second trial (Köhler, 1997) was undertaken to investigate the effect of CRINA for POULTRY on the colonisation of the intestine of broilers with *Clostridium perfringens*. Two group of ca. 30,000 animals on a wheat, soya, peas diet were compared. The control group contained 20 p.p.m. Zinc Bacitracin while in the experimental group, the Zinc Bacitracin was substituted with 50 p.p.m. CRINA for POULTRY (Table 4).

Table 4. Effect of CRINA for POULTRY on the development of *Clostridium perfringens* in broilers

	Zn-Bacitracin	CRINA
Rate of detection (%)		
Total	52	26
Ileum	50	33
Caecum	50	23
Colon	57	20
5th day	47	33
18th day	30	20
32nd day	80	23
Average concentration (log x)	0.80	0.32

The supplementation of CRINA for POULTRY in the feed reduced the concentration of *Cl. perfringens* in the ileum, caecum and colon. Moreover it decreased the number of animals infected with *Cl. perfringens* at day 32 by 70%. As a consequence it increased the development of the body weight in comparison with Zinc Bacitracin.

From these results it can be inferred that the EO blend CRINA for POULTRY seems to be able to control the colonisation of the intestine of broilers with *Cl. perfringens*. The stimulation of animal growth is probably the consequence of the increased availability of the natural antagonists, in the intestinal ecosystem, of *Cl. perfringens*. From the reduction of *Cl. perfringens* in the presence of CRINA for POULTRY in the lower intestinal tract (caecum and colon) and because of the nature of the product, it can be inferred that the effects of the product are due partly to a direct inhibition of the bacteria and partly through the change in substrate, consequence of the enzymes stimulation.

The combined activities of the EO result in an increase in animal performance. In diary cows this is characterised by improved milk production and quality, in monogastric the effect is to improve feed efficiency and daily weight gain as shown in the next trial.

The experiment (Cadogan *et al.*, 1999) was conducted to try and establish the modes of action of CRINA for PIGS, at least as it affects protein and energy availability and/or metabolism. This was achieved by measuring the performance of female and male pigs offered a series of control diets or diets supplemented with CRINA for PIGS. These ranged from deficient to adequate in amino acids.

A 2 x 2 x 5 factorial design trial was carried out. The factors were: sex (entire male and female), CRINA for PIGS (zero and 75 p.p.m.) and dietary "Lysine" (0.35, 0.40, 0.45, 0.50 and 0.55 g available Lysine: MJ DE). 200 pigs comprising equal numbers of males and females were allocated at 80 kg among the 10 dietary treatments (10 pigs/treatment). The results for growth performance during the 0 to 21-day period are shown in Table 5.

Table 5. Effects of Crina and available lysine on the growth performance
of male and female finishers commencing at 80 kg live weight
offered experimental diets for 21 days

Available lysine (g/MJ DE)	Crina	Final wt (kg)	Daily gain (g)	Feed intake (kg/d)	Feed:gain
0.35	–	102.7	1040	2.933	2.87
0.35	+	104.4	1110	3.058	2.80
0.40	–	102.6	1045	2.887	2.79
0.40	+	103.3	1085	2.872	2.68
0.45	–	102.2	1034	2.927	2.91
0.45	+	104.0	1105	2.845	2.61
0.50	–	102.9	1061	2.834	2.78
0.50	+	103.3	1089	2.856	2.65
0.55	–	104.1	1095	2.857	2.69
0.55	+	103.8	1103	2.774	2.60
SEM		0.397	13.43	0.022	0.33
Significance					
Two way analysis					
Sex (S)		0.115	0.000	0.006	0.000
Lysine (L)		NS	NS	0.109	NS
Crina (C)		NS	0.107	NS	0.007
S x L		NS	NS	NS	0.039
S x C		NS	NS	NS	0.075
L x C		NS	NS	NS	NS
S x L x C		NS	NS	NS	NS

NS, not significant (P > 0.10).

The results for the 0 to 21 day period showed that males grew faster, ate less and exhibited superior FCR compared to females. There was an interaction on FCR (P = 0.039) between lysine and sex. Males significantly responded in FCR to the highest level of available lysine, whereas females did not respond to increasing lysine. Crina significantly improved FCR (P = 0.007), and had a tendency to improve daily gain (P = 0.107). Crina, however, produced a more pronounced effect on the FCR (sex by Crina interaction; P = 0.075) of females.

During the 0 to 28-day period (not shown), the results showed males were more efficient than the females. Increasing available lysine significantly improved FCR (P = 0.004), and this effect was more pronounced in male pigs (P = 0.008) responding up to 0.55 g/MJ DE. Females growth performance was not influenced by increasing available lysine. There was no significant effect of Crina on the growth performance of combined sexes. There was, however, a significant interaction on FCR between sex and Crina (P = 0.051). Crina significantly improved FCR of females; however, there was no effect on males, lysine being the limiting factor.

Female carcass weight was higher at the available lysine level of 0.40 g/MJ DE, although there was little difference at other dietary lysine levels (P = 0.003; interaction sex x lysine, P = 0.078). Females dressed better (P < 0.001), and were fatter at the P2 (P < 0.001) and leg (P < 0.001) site measurements, compared to the males. Available lysine level had no effect on carcass weight, but had a tendency to reduce dressing percentage (P = 0.095), and reduce fat thickness at the P2 (P = 0.074). Crina had no significant effect on carcass quality measurements. There was, however, a tendency for an interaction on dressing percentage between Crina and dietary lysine. Crina maintained dressing percentage at the highest lysine levels, while pigs offered the highest lysine control diets had a significantly lower dressing yield. There was also a trend for Crina to increase leg fat of males, but reduce leg fat in females (P = 0.105).

Males had a significantly lower carcass fat than females (P < 0.001). Increasing available lysine reduced carcass fat percentage (P = 0.033). There was a trend for an interaction for carcass fat percentage between sex and Crina supplementation (P = 0.122). Females tended to have lower carcass fat on the Crina supplemented diets, whereas males tended to be fatter. Males exhibited lower BUN's than females (P = 0.067). Crina increased the BUN measurement (P = 0.075), however, there was an interrelationship on BUN between sex, available lysine and Crina (P = 0.034). Female BUN was higher with increasing dietary lysine, Crina increased BUN further with rising lysine, but there was no effect of crina or available lysine on the BUN of males.

Conclusions

EO can be considered one of the tools for animal nutritionist to maintain flexibility when formulating animal feeds. Although further research must be carried out to understand all the mechanisms and potentials of those active molecules there is little doubt that animal performance can be improved through their use.

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