ABSTRACT

The effects of adding 2% of natural zeolite, containing a high percentage of clinoptilolite, to the diet of piglets was evaluated by monitoring growing performance and plasma parameters. The diet was also deprived of Colistine, an antibiotic usually added to piglet diets at subtherapeutic levels to prevent gastrointestinal pathology. Sixty-four piglets, weaned at 7.9 kg live weight, were divided in 2 groups of 32 each. The control group was given commercial piglet feedstuffs; for the treated group, 98% of the same feed, deprived of Colistine, was used, with the addition of 2% of a natural zeolite. The trial lasted 36 days. The piglets fed the control diet exhibited greater weight in the first three weeks, after which the differences were not significant. The average daily weight gain in the first week was higher in the control group (+37%; P<0.01) whereas at the end of the trial no differences were found. The feed intake did not show significant differences between groups and, as a result, the Feed Efficiency at the end of the trial was higher in the control group (532 vs. 491, P< 0.05). The plasmatic nitrogen parameters did not show significant differences between groups. Only in the first three weeks post-weaning the group fed the diet containing Colistine showed better ADG, subsequently it can be eliminated and clinoptilolite could favour growth.

Key words: Piglets, Clinoptilolite, Colistine, Performance parameters, Plasmatic nitrogen parameters

RIASSUNTO

UTILIZZO DI UNA CLINOPTILOLITE NELLA DIETA DEL SUINETTO, COME SOSTITUTO DELLA COLISTINA.

In questo studio si è inteso valutare gli effetti dell'addizione di una zeolite naturale in quantità del 2% nella razione di suinetti, attraverso la valutazione dei parametri produttivi e di alcuni parametri ematici del metabolismo azotato in una dieta in cui è stata eliminata la Colistina, principio antibiotico impiegato a mezzo preventivo per il controllo di diarrea ed enteriti nel periodo post-svezzamento. Per la sperimentazione sono stati impiegati 64 suinetti LargeWhite x Landrace, metà maschi castrati e metà femmine, provenienti da 8 nidiate, svezzati al peso medio di 7,9 kg, divisi in 2 gruppi di 32 animali ed allevati in box da 8 animali ciascuno all'interno del medesimo locale. Il gruppo di controllo è stato alimentato con un mangime completo per suinetti mentre la razione del gruppo trattato era composta per il 98% dallo stesso mangime del controllo, privato della Colistina, più il 2% di una zeolite naturale ad alto contenuto di clinoptilolite. Ogni settimana sono stati determinati il peso individuale (BW) dei suinetti, l'incremento medio giornaliero (ADG), e alcuni parametri plasmatici relativi al metabolismo azotato. A fine prova si è determinata l'ingestione giornaliera di alimento (FI) e calcolato l'efficienza alimentare (FE). Il gruppo di controllo ha evidenziato BW e ADG superiori nelle prime tre settimane post-svezzamento.
(dopo 7 giorni BW +10%; P<0.01; ADG +37%, P<0.01), mentre in seguito le differenze, seppur confermate, non risultano più significative. L’ingestione giornaliera non ha evidenziato differenze significative e pertanto l’FE è risultato superiore nel gruppo di controllo (352 vs 491, P<0.05). I parametri plasmatici non hanno fatto registrare differenze significative, seppur i contenuti di urea e creatinina risultino inferiori nel gruppo trattato, probabilmente a causa dell’effetto adsorbente delle zeoliti. In conclusione la riduzione dell’incremento ponderale giornaliero e del peso vivo del gruppo alimentato con una dieta contenente il 2 % di zeolite è avvenuto nelle prime tre settimane, soprattutto nella prima, pertanto, in seguito, essa può venire eliminata e parzialmente sostituita con la zeolite quale promotore di crescita.

Parole chiave: Suinetti, Clinoptilolite, Colistina, Prestazioni produttive, Parametri plasmatici azotati

Introduction

The post-weaning period is a critical moment in swine rearing. The removal from the mother and the introduction into new rooms with several animals cause considerably stressful conditions for piglets. Furthermore, the change in diet from liquid to solid feed increases the discomfort of piglets and may induce serious pathologies in digestive apparatus. As a result, serious diarrhoea can occur which represents the most frequent cause of death in piglets before 56 days of age (Beers-Schreuers et al., 1992; Gupta and Iyer, 1984).

Subtherapeutic levels of antibiotics have been postulated to prevent diarrhoea; as side effect they can promote growth of animals and improve feed efficiency. The mechanisms of growth promotion by antibiotics include different aspects: they modify the activity of gastrointestinal mucosa, they regulate the absorption of alimentary constituents, influence the activity of the endocrine system and modify the microflora and their products within the gastrointestinal lumen (Visek, 1978). The antibiotic action on the microflora determines great changes in the concentration and in the metabolism of bacteria in the gastrointestinal tract, causing alterations to the absorption, to the motility and to the glandular activity of digestive apparatus. As a result, the incidence of diarrhoea can be reduced. According to Yen and Pond (1990) subtherapeutic levels of antibiotics reduce the bacterial production of ammonia in the intestinal tract and lower its blood concentration, thus increasing the growth of the animals (Visek, 1978). The addition of natural zeolites is assumed to have a similar effect to that of antibiotics, as clay has a great affinity to ammonia. Many studies have been conducted regarding the use of natural zeolites in pig feeds, because of the positive effects it could have on animal health and metabolism. Positive effects on average daily weight gain and on feed conversion rate were observed by Kondo et al. (1969), Han In et al. (1976), Lee et al. (1970), Vrzgula and Bartko (1984) and Castro and Pastrana (1988); on the contrary Shurson et al. (1984) observed that dietary inclusion of 2.5%, 5% and 7.5% of zeolite caused a proportional reduction in the utilization of protein in piglets. Zeolites have particular chemical-physical properties that determine a strong stability of its structure which is not modified by pH values in the gastrointestinal tract. Zeolites have a great ammonia-binding capacity (Barrer, 1978) and for this reason they also act as detoxicant agents along the gastrointestinal tract (Sardi et al., 2002).

Many authors have observed a large increase of the contents of dry matter of the faeces (Malagutti et al., 1997; Benatti et al., 1994; Monetti et al., 1996) showing positive effects in the prevention of diarrhoea and in the operation of cleaning and removing of manure from piggy.

In this study, the effects of adding 2% of natural zeolite, containing a high percentage of clinoptilolite, in the diet of piglets have been evaluated by observing growing performance parameters and plasma parameters. The diet has been also deprived of Clositine, antibiotic normally added to the diet of piglets at subtherapeutic levels to promote growth.

Material and methods

Sixty-four Large White x Landrance piglets, half castrated males and half females, from 8 litters, weaned at mean live weight of 7.9 kg, were
USE OF CLINOPTILOLITE IN PIGLET DIETS

Table 1. Chemical and mineralogical properties of the zeolite used

| Property          | Control | Zeolite |
|-------------------|---------|---------|
| SiO₂              | 64.27%  |         |
| Al₂O₃             | 13.72%  |         |
| CaO               | 4.96%   |         |
| H₂O               | 3.44%   |         |
| Fe₂O₃             | 2.74%   |         |
| Na₂O              | 2.21%   |         |
| Clinoptilolite+Mordenite | 65%     |
| Quartz+Calcite+Feldspar | 35%     |

Table 2. Composition (g/kg feed) of the diets

| Component                  | Control  | Zeolite |
|----------------------------|----------|---------|
| Barley meal                | 413.0    | 404.8   |
| Non dehulled barley flakes | 150.0    | 147.0   |
| Premix DENKAVIT®           | 80.0     | 78.4    |
| Extruded soybean           | 73.0     | 71.5    |
| Soybean meal               | 44.0     | 43.1    |
| Maize meal                 | 60.0     | 58.9    |
| Wheat sharps               | 50.0     | 49.0    |
| Milk yield                 | 85.0     | 83.5    |
| Fish meal                  | 25.0     | 24.5    |
| Molasses                   | 10.0     | 9.8     |
| Lard                       | 10.0     | 9.8     |
| Zeolite                    | 0        | 20.0    |

Table 3. Chemical composition of the diets

| Component     | Control | Zeolite |
|---------------|---------|---------|
| Dry matter %  | 89.56   | 90.03   |
| Crude protein | 16.22   | 15.97   |
| Crude fibre   | 3.58    | 3.53    |
| Ether extract | 5.57    | 5.48    |
| Ash           | 6.17    | 7.99    |
| Lysine        | 1.10    | 1.08    |
| Met.+Cys      | 0.64    | 0.63    |
| Threonine     | 0.74    | 0.73    |
| Tryptophan    | 0.21    | 0.20    |
| Colistine mg/kg| 120     | ==      |
| Net energy Kcal/kg| 2337   | 2290    |

The piglets were divided in 2 groups of 32 animals each and housed in pens which held 8 animals. The piglets were homogeneously chosen with respect to sex and weight. The control group was given commercial piglet feedstuffs (Control diet). For the treated group, 98% of the same feed was used with the addition of 2% of a natural zeolite containing a high percentage of clinoptilolite (Zeolite diet). The main chemical and mineralogical properties of the zeolite used are displayed in Table 1. Furthermore, the treated group was totally deprived of Colistine, an antibiotic present in the control diet for 120 mg/kg. The diets were provided ad libitum and the animals had free access to drinking water. The composition of the diets is shown in Table 2 and the analytical characteristics of the diets in Table 3. The chemical analysis of feedstuffs was carried out in accordance with the recommendations of the Italian Association for Animal Production (ASPA, 1980).

The piglets were individually weighed at the beginning of the trial and once a week for the following 5 weeks. The trial lasted a total of 36 days. Data were recorded weekly regarding Live Body Weight (BW) and Average Daily Weight Gain (ADG), along with collection of blood samples. On the same 8 animals from every group, blood samples were collected in test tubes containing EDTA 2 hours after feeding. Blood samples were centrifuged (3000 rpm x 10 min.) and plasma stored at -20°C. Plasma parameters (uric acid, urea, creatinine, total protein) were determined using enzymatic spectrophotometer assays (Biochemia Boehringer, Italia) while α-amino-nitrogen was determined using the Goodwin method. The Feed Intake (FI) of each pen was recorded at the end of the trial to calculate the Feed Efficiency (FE).

Statistical analysis

All data were analysed by ANOVA according to General Linear Model of the S.A.S. package (1994) in order to evaluate the effects of diet. The Live Body Weight and the Average Daily Weight Gain recorded during the study were
covaried with the initial BW. The statistical model employed for the BW and ADG was the following:

$$Y_{ij} = \mu + \alpha_i + \beta (x_i - \bar{x}) + \gamma k + \epsilon_{ijk}$$

where $\mu$ was the general average, $\alpha$ was the effect of the diet, $\beta$ was the correction factor for the covariate, $x$ was the average of the observations, $\gamma$ was the error. A statistical model without the effect of the pen and without correction factor for the covariate was employed for plasma parameters, Feed Efficiency and Feed Intake.

**Results and discussion**

All piglets were in good health before and throughout the trial. Firm faeces were observed throughout the study with no occurrence of diarrhoea. No significant differences between the groups were observed as attributable to pen effect. The Live Body Weights of piglets are reported in Table 4. The piglets were weighed every week and significant differences were observed in the first 3 weeks; the piglets fed the control diet showed greater weight: 9503g vs. 8653g ($P<0.01$) after 7 days, 12767g vs. 11686g ($P<0.01$) after 14 days and 16884g vs. 15420g ($P<0.01$) after 21 days. At the end of the trial, the differences were not statistically significant. The Average Daily Weight Gain is shown in Table 5. The ADG showed the same trend that BW did. The higher values were observed in the control group during the whole experimental period, although the differences were not significant in the last 2 weeks. The overall ADG was 508 g/d.

**Table 4. Live body weight of piglets**

|                     | Control | Zeolite | SE  | $P$ |
|---------------------|---------|---------|-----|-----|
| Initial body weight | g       | 8035    | 7842| 208 | ns |
| Live body weight 7 d| "       | 9503    | 8653| 127 | P<0.01 |
| Live body weight 14 d| "       | 12767   | 11686| 268 | P<0.01 |
| Live body weight 21 d| "       | 16884   | 15420| 344 | P<0.01 |
| Live body weight 28 d| "       | 20835   | 19875| 445 | ns   |
| Live body weight 36 d| "       | 26290   | 24648| 603 | ns   |

$ns: P>0.05$

**Table 5. Growing parameters of piglets**

|                     | Control | Zeolite | SE   | $P$   |
|---------------------|---------|---------|------|-------|
| ADG 7 d             | g/d     | 234     | 146  | 15.8  | P<0.01 |
| ADG 14 d            | "       | 341     | 281  | 17.4  | P<0.05 |
| ADG 21 d            | "       | 423     | 343  | 16.8  | P<0.01 |
| ADG 28 d            | "       | 442     | 397  | 16.1  | ns    |
| ADG 36 d            | "       | 508     | 466  | 17.4  | ns    |
| Feed Intake         | "       | 961     | 955  | 33.0  | ns    |
| Feed efficiency     | g gain/kg feed | 532 | 491 | 22.4 | P<0.05 |

$ns: P>0.05$
for the control group and 466 g/d for the treated group fed a diet without Colistine. It stands to reason that Colistine is efficient until the third week; in the first week especially the ADG of the treated group is lower (-37%), whereas in the following weeks the differences reduce. The lower ADG also depends on the lower energy and protein content of the diet with the addition of 2% of zeolite, which is an inert material. In fact, the amount of energy for the maintenance of animals is unvaried, while the amount of energy available for growth is much lower than 2% in the diet with zeolite added. The lower energy and the absence of antibiotics reduced the ADG, even though no enteritic syndrome with diarrhoea was observed and no veterinary treatments were necessary.

The Feed Intake of the animals did not show significant differences between groups and, as a result of the lower ADG of the treated group, the FE at the end of the trial was higher in the control group (532 vs. 491, P< 0.05). The decrease in ADG and FE confirms the conclusions of Poulsen and Oksbjerg (1995) who suggested that the animals were unable to compensate for the energy diluting effect of zeolite by increasing the feed intake. The plasma parameters reported in Table 6, are consistent with previous studies on piglets of the same age (Bassaganya-Riera et al. 2001, Parisini et al. 1989). No significant differences were found, but piglets fed the diet containing zeolite showed a tendency toward a lower content of urea (P<0.09) and creatinine (P<0.11), probably because of the absorption of excess ammonium by zeolite in the gastrointestinal tract, which causes a reduction of plasmatic urea.

**Conclusions**

The piglets fed the diet with the clinoptilolite and without Colistine showed a decrease in ADG and an increase in FE. The differences were higher in the first week and reduced in the following weeks, so the effect of Colistine cannot be disregarded during first 7 days post-weaning. Subsequently Colistine can be excluded from the diet and zeolite may have positive effects on animal health and metabolism by possibly absorbing ammonia in the gastrointestinal tract.

The addition of clinoptilolite to the diet of piglets in the amount of 2% of total feed is not sufficient to determine significant differences in plasma parameters concerning nitrogen metabolism.

The paper must be attributed equally to the authors.

**REFERENCES**

ASPA, Commissione Valutazione degli alimenti, 1980. Valutazione degli alimenti di interesse zootecnico. 1. Analisi chimica. Zoot. Nutr. Anim. 6:19-34.

BARRER, R.M., 1978. Zeolites and clay minerals as sorbents and molecular sieves. Academic Press, London, New York, San Francisco.

BASSAGANYA-RIERA, J., HONTECILLAS-MAGARES, R., BREGENDHAL, K., WANNEMUEHLER, M.J., ZIMMERMAN, D.R., 2001. Effects of dietary conjugated linoleic acid in nursery pigs of dirty and clean environments on growth, empty body composition, and immune competence. J. Anim. Sci. 79:714-721.
MALAGUTTI et al.

BEERS-SCHREUERS, H.M.G., WELLENGA, L., WENSING, T., BREUKINK, H.J., 1992. The pathogenesis of the post-weaning syndrome in weaned piglets: a review. Vet. Quart. 14:29-34.

BENATTI, G., BERGERO, D., LADETTO, G., SARRA, C., 1994. Effetto di una zeolite a phillipsite su alcuni parametri di digeribilità in suini. Zoot. Nutr. Anim. 20:153-158.

CASTRO, M., PASTRANA, M., 1988. The effect of different levels of zeolite on the performance of growing swine. Pigs Misset. 2:12-13.

GUPTA, S.C., IYER, P.K.R., 1984. Mortality pattern and its causes among pigs. Indian Vet. Journal. 61:448-450.

HAN IN, K., CHUN, S., 1976. Studies on the nutritive value of zeolite. 1. Substitution levels of zeolite for wheat bran in the rations of growing-finishing swine. Korean J. Anim. Sci. 17:595-599.

KONDO N., WAGAI B., KANAE, H., FIJISHIRO, S., SUZUCHI, F., TAGA, (1969). Effect of zeolites on calf growth. Chikusan No kenikyu, 23:987.

LEE, Y.C., TZENG, C.M., LAI, M.K., TSAI, A.H., 1979. Natural zeolite powder replacing antibiotic additives for fattening pigs. Korean J. Anim. Sci. 6:38.

MALAGUTTI, L., ZANINOTTI, M., MOLTENI, L., SCIARAFFIA, F., 1997. Riduzione del contenuto proteico nella dieta del suino pesante: effetti sull'escrezione azotata e sulle prestazioni produttive. pp 171-178 in Proc. Nat. Congr. Parliamo di...alimentazione animale e ambiente, Fossano (CN), Italy.

MONETTI, P.G., TASSINARI, M., VIGNOLA, G., GONZALEZ VALDES, J.L., 1996. Bilancio azotato e digeribilità apparente di alcuni nutrienti in suini alimentati con diete contenenti una zeolite naturale. Zoot. Nutr. Anim. 22:159-169.

PASINI, P., SCIPIONI, R., MARCHETTI, S., MORDENTI, A., 1989. Effetti della componente peptidica di un proteolisato nella nutrizione del suineto. Zoot. Nutr. Anim. 15:637-644.

POULSEN, H.D., OKSBJERG, N., 1995. Effects of dietary inclusions of a zeolite (clinoptilolite) on performance and protein metabolism of young growing pigs. Anim. Feed Sci. Tec. 53:279-296.

SARDI, L., MARTELLI, G., PASINI, P., CESSE, E., MORDENTI, A., 2002. The effects of clinoptilolite on piglet and heavy pig production. Ital. J. Anim. Sci. 1:103-111.

SAS/STAT, 1994. Release 6.10. Sas Inst. Inc., Cary, NC, USA.

SHURSON, G.C., KU, P.K., MILLER, E.R., YOKOYAMA, M.T., 1984. Effects of Zeolite A or clinoptilolite in diets of growing swine. J. Anim. Sci. 59:1536-1545.

VIZEK, W. G., 1978. The mode of growth promotion by antibiotics. J. Anim. Sci. 46:1447-1469.

VIZIOULA, L., BARTKO, P., 1984. Effects of clinoptilolite on weight gain and some physiological parameters of swine. In: W.G. Pond and F.A. Mumpton (eds.) Zeo-agriculture: use of natural zeolites in agriculture an aquaculture. Westview Press, Boulder, Colorado, USA, pp 157-162.

YEN, J.T., POND, W.G., 1990. Effect of Carbox on net absorption of ammonia and glucose into hepatic portal vein of growing pigs. J. Anim. Sci. 68:4236-4242.

