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The piglets as an experimental model for elucidating effects of Availa-Zn-170 on growth performance, blood profile and nutrient digestibility.

WB Chen[1], F Ji[2], D Liu[1], TL Ward[2], RJ Fang[1]*

[1]College of Animal Science and Technology, Hunan Agricultural University, Changsha, 410128, PR. China

[2]Zinpro Corporation 10400 Viking Drive, Suite 240, Eden Prairie, Minnesota, 55344, USA.

Abstract

The weaned piglet is a model for zinc deficiency in children. This study aimed comparing growth and nutrient digestibility of piglets with or without Availa-Zn-170 on diets. Two hundred and eighty-eight 7.5 ± 0.4 kg piglets, weaned at the age of 25d, were used to evaluate the effects of Availa-Zn-170 (17% amino acid zinc) on growth performance, blood profile, and apparent total tract digestibility of crude protein and digestible energy. Six dietary treatments were used: (1) Control diet without Zn supplementation (CON), (2) CON+20 mg/kg Availa-Zn-170 (Availa-Zn-20), (3) CON+40 mg/kg Availa-Zn170, (Availa-Zn-40), (4) CON+60 mg/kg Availa-Zn-170 (Availa-Zn-60), (5) CON+80 mg/kg Availa-Zn-170 (Availa-Zn-80), (6) CON+80 mg/kg feed grade zinc sulphate (Zinc sulphate-80). Our results showed during the overall period, piglets fed Availa-Zn-40 or Availa-Zn-80 had greater ($P<0.05$) average daily gain and G: F compared with other diets. Dietary treatments did not affect the apparent total tract digestibility of crude protein and gross energy determined on d 40. Compared with the control, the concentration of serum Zn on d 14 and 40 increased when Availa-Zn-170 was added. The results indicate that Availa-Zn-170 could be an effective organic zinc use as alternative to inorganic zinc to increase the growth performance and nutrient digestibility of weaned piglets.

Key words:

Blood profile, Diarrhea rate, Growth performance, Nutrient digestibility, Weaned piglets, Zinc.

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Introduction

Zinc in human milk appears to be more efficiently utilized by the human infant than that in cow's milk or commercial baby foods based on cow's milk. Plasma Zn concentrations of breast-fed infants are significantly higher than those of infants given baby foods, with or without supplementary Zn [1]. In attempts to explain this observation it has been hypothesized that low-molecular-weight Zn-binding ligands specific to human milk, e.g. citrate [2] and picolinic acid [3], may facilitate Zn uptake across the small intestine. However, when human and cow's milks were analysed on a column of Sephadex G-150 under non-dissociating conditions, all the Zn was recovered in forms bound to high-molecular-weight-protein complexes. In cow's milk, Zn was bound to casein and was not released during the partial dissociation of the micelles. In human milk, Zn was associated with a protein complex the major component of which was characterized as lactoferrin. In addition, Zn in intestinal cell cytosol and pancreatic secretions was entirely present in protein-bound forms provided precautions were taken to minimize proteolysis.

In recent years, chelated or organic zinc has been a subject of active research in animal nutrition and it is reported that that the addition of organic zinc can promote animal growth, and reproductive performance and health [4]. Compared with $ZnSO_4$ (100%). According to the Diet component, the biological activity of Zn-Met was between 117% and 206% [5-7]. Zn-Met can improve zinc bioavailability, can enhance immune function and has good compatibility and synergistic effect with a variety of nutrients. It also can increase the vitamin retention rate [8]. Zhang et al. (2010) studied the effect of feeding different concentrations of zinc (Zn), from organic and inorganic sources, on growth performance of weaned pigs. Overall in the experiment, pigs fed of 100 ppm additional Zn (40% $ZnSO_4$ and 60% Zn-AAC) had higher ADG than pigs fed 100 ppm additional Zn ($ZnSO_4$) ($P<0.05$). FCR of all the treatments was slightly higher. Weaned pig performance was improved when fed of conventional concentration of Zn (Zn-AAC).

Knowledge of the bioavailability of dietary Zn and health effects of early exposure is of paramount importance to improve the risk assessment of Zn for children. The assimilation of dietary protein is associated with a cascade of transient and dynamic metabolic processes involved in controlling the distribution of amino acids and nitrogen throughout the body. Therefore, safe organic zinc preparation with high efficiency and good nutrition value is important when weaned piglets as an experimental model. This study was conducted to evaluate the effect of Availa-Zn-170, which is a zinc amino acid chelate (Zn content, 17%) on growth performance, blood profile, and apparent total tract digestibility (ATTD) of nutrients.

Materials and Methods

The experimental protocol describing the management and animal care was reviewed and approved by the Animal Experimental Committee of Hunan Agricultural University and accord with the University guidelines for animals Care.

Animals and facilities

A total of 288 piglets (Duroc × Landrace × Large white, about 7.5 ± 0.4 kg) weaned at the age of 25 d were used in this experiment. There were two phases in this experiment: Phase 1 (from d 0 to 14) and Phase 2 (from d 14 to 40). Pigs were randomly allotted to 6 experimental diets according to their initial BW and sex (4 gilts and 4 barrows/pen; 6 pens/ treatment).

All piglets were housed in an environmentally controlled room, which provided 0.25 m^2 and 0.55 m^2 for each pig in Phases 1 and 2, respectively. Each pen was equipped with stainless-steel self-feeder and a nipple drinker that allowed pigs unlimited access to feed and water. Feed intake and Diarrhea data were recorded daily; all the piglets were individually weighed on d 0, 14 and 40. Pig BW and feed intake were recorded weekly for both phases to determine ADG, ADFI, and G:F.

Dietary treatments

Availa-Zn-170 is a complex of amino acid and zinc (17% Zn) that is manufactured by Zinpro Animal Nutrition Corporation, USA. There were 6 dietary treatments including:

1) Control diet without Zn supplementation (CON)

2) CON+20 mg/kg Availa-Zn-170 (Availa-Zn-20)

3) CON+40 mg/kg Availa-Zn-170, (Availa-Zn-40)

4) CON+60 mg/kg Availa-Zn-170 (Availa-Zn-60)

5) CON+80 mg/kg Availa-Zn-170 (Availa-Zn-80)

6) CON+80 mg/kg feed grade zinc sulphate (Zinc sulphate-80).

The diets were fed during the experiment in 2 phases: Phase 1(day 0 to 14), Phase 2 (day 14 to 40).

Diets in each of the 2 phases were formulated to meet or exceed the nutrient requirements (NCR 1998) for weaned piglets (**Table 1**) and fed in a mash form. Treatment additives were included in the diet by replacing corn.

Table 1*: Dietary composition and calculated nutrient content, as-fed basis.* ***1****-Vitamin premix provided per kilogram of diet: vitamin A, 15,000 IU; vitamin D3, 200 IU; vitamin E, 85 IU; D-pantothenic acid, 35 mg; vitamin B2 12 mg; folic acid 1.5 mg; nicotinic acid 35 mg; vitamin B1 3.5 mg; vitamin B6, 2.5 mg; biotin, 0.2 mg; vitamin B12, 0.05 mg.* ***2****-Trace mineral premix provided per kilogram of diet: Cu (as $CuSO_4{\cdot}5H_2O$),150 mg; Fe (as $FeSO_4{\cdot}7H_2O$),100 mg; Mn (as Mn $SO_4{\cdot}H_2O$),60 mg; I (as KI), 1 mg; Se (as $NaSeO_3{\cdot}5H_2O$), 0.35 mg; Co (as $CoSO_4{\cdot}7H_2O$) 0.4 mg.*

Item		Phase 1 (d0 to 14)	Phase 2 (d 14 to 40)
Ingredient (%)	Extruded Corn	55.55	60
	Dehulled soybean meal, 46% CP	8	12
	Extruded soybean	8	8
	Whey powder, 3% CP	5	—
	Fermented soybean meal	10	6
	Sugar	2.5	2.5
	Plasma protein powder	3.5	—
	Fish meal, 64% CP	—	2.5
	Soy protein concentrate, 66% CP	—	2
	Soybean oil	2	2
	L-Lys.HCL, 78%	0.36	0.28
	DL-Met, 50%	0.2	0.12
	L-Thr	0.13	0.1
	L-Trp	0.11	0.05
	Choline chloride, 50%	0.15	0.15

	Vitamin premix1	1	1
	Trace mineral premix2	1.5	1.5
	Monocalcium phosphate	0.8	0.7
	Limestone	1	0.9
	Salt	0.2	0.2
	Total	100	100
Calculated composition	DE, MJ/kg	14.7	14.5
	CP, %	20.5	20
	Lys , %	1.45	1.3
	Met , %	0.48	0.44
	Thr, %	0.95	0.84
	Try, %	0.29	0.26
	P, %	0.6	0.6
	Ca, %	0.7	0.7

Sampling and measurements

For the serum or blood profiles, 2 pigs (1 gilt and 1 barrow) from each pen were randomly selected, and 10 ml blood samples were collected via anterior vena cava puncture on day 0, 14, and 40. Blood samples collected were placed into glass tubes without anticoagulant, and centrifuged at 3000 × g for 10 min at 4, and the resulting serum was stored at -80for alkaline phosphatase (ALP), superoxide dismutase (SOD), and zinc content analysis. Alkaline phosphatase and zinc content were analyzed with the BS-200 fully automatic biochemical analyzer. The SOD content was analyzed using Enzyme reagent kit.

Apparent total tract digestibility of CP and gross energy was determined using acid-insoluble ash as inert digestibility indicator. Fresh fecal grab samples collected from three piglets of every pen were mixed with 10% sulfuric acid and pooled, and a representative sample was stored in a freezer at -80 until analyzed on d 14 and d 40. Before chemical analysis, the samples were thawed and dried at 56 for 72 h, after which they were finely ground to a size that could pass through a 0.38-mm screen. All feed and fecal samples were analyzed for CP and DE following the procedures outlined by the AOAC (2000) [10]. Gross energy was determined by measuring the heat of combustion in the samples using a Parr 6100 oxygen bomb calorimeter (Parr instrument Co., Moline, IL,USA).

The digestibility was calculated using the following formula:

Digestibility (%)=1-(Nf × Cd)/(Nd × Cf)× 100,

Where NF=Nutrient concentration in feces (% DM), ND=Nutrient concentration in diet (%DM), CF=Acid-insoluble ash concentration in feces (% DM), and CD=Acid-insoluble ash concentration in feces (% DM).

Statistical analysis

All data were subjected to the statistical analysis as randomized complete block design using the GLM procedures (SAS Inst. Inc., Cary, NC), and the pen was used as the experimental unit. Growth performance for all response criteria was calculated on a pen basis. Differences between treatments were determined using Duncan's Multiple Range Test $P<0.05$. Results were considered significant at $P<0.05$.

Results

Growth performance

During the experiment, there were no differences in BW among all the treatments. (Table 2). Compared with the control, piglets fed the 40 mg/kg Availa-Zn-170 diet had greater ADG in Phase 1 ($P<0.05$). Availa-Zn-80 had greater ADG in Phase 2 ($P<0.05$), Piglets fed of Availa-Zn-40 and Availa-Zn-80 had greater ADG during the overall period ($P<0.05$). During the Phase 1 (day 0 to 14) and the overall period (day 0 to 40), no effects among treatments were observed on ADFI, but Availa-Zn-80 and Availa-Zn-40 improved ($P<0.05$) ADFI of piglets compared with CON. During Phase 1 (day 0 to 14), Zinc sulphate-80 decreased G: F of piglets ($P<0.05$), but G: F tended to increase when Availa-Zn-170 was added. During the Phase 2 (day 14 to 40) and the overall period (day 0 to 40), Availa-Zn-80 improved G: F of piglets compare with CON ($P<0.05$).

Diarrhea rate

During the Phase 1 (day 0 to 14) and the overall period (day 0 to 40), the diarrhea rate of piglets fed of Availa-Zn-40 and

Availa-Zn-60 were higher than that of CON (P<0.05), which was higher than normal (**Table 2**).

Table 2: *Effects of Availa-Zn170 on growth performance and diarrhea rate in weaned piglets[1]. ^{a,b}Within a row, means without a common superscript differ (P<0.05). [1]Each mean represents 6 pens with 8 pigs per pen. Each dietary treatment were as follows: CON=control diet; Availa-Zn-20=control diet+20 mg/kg Availa-Zn170; Availa-Zn-40=control diet+40 mg/kg Availa-Zn-170; Availa-Zn-60=control diet+60 mg/kg Availa-Zn-170; Availa-Zn-80=control diet+80 mg/kg Availa-Zn170; Zinc sulphate-80=control diet+80 mg/kg feed grade zinc sulphate.*

Item		CON	Availa-Zn-20	Availa-Zn-40	Availa-Zn-60	Availa-Zn-80	Zinc sulphate-80	SEM	P-value
BW, kg	d 0	7.62	7.38	7.67	7.53	7.51	7.7	0.4	0.66
	d 14	10.78	10.55	11.43	10.77	10.54	10.55	0.98	0.75
	d 40	20.8	20.55	21.99	20.37	22.14	21.27	1.63	0.13
ADG, g	Phase 1 (d 0 to 14)	226^{b}	243^{b}	269^{a}	246^{b}	238^{b}	218^{b}	10	P0.05
	Phase 2 (d 14 to 40)	401^{b}	400^{b}	422^{b}	386^{b}	464^{a}	429^{b}	7	P0.05
	Overall (d 0 to 40)	338^{b}	338^{b}	367^{a}	331^{b}	375^{a}	356^{b}	4	P0.05
ADFI, g	Phase 1 (d 0 to 14)	350	352	384	369	334	360	5	0.551
	Phase 2 (d 14 to 40)	688^{b}	673^{b}	720^{a}	645^{b}	727^{a}	705^{b}	9	P0.05
	Overall (d 0 to 40)	567	558	599	544	586	587	4	0.118
G:F, g/g	Phase 1 (d 0 to 14)	0.64^{a}	0.67^{a}	0.70^{a}	0.67^{a}	0.69^{a}	0.58^{b}	0.27	P0.05
	Phase 2 (d 14 to 40)	0.58^{b}	0.59^{b}	0.58^{b}	0.59^{b}	0.63^{a}	0.59^{b}	0.03	P0.05
	Overall (d 0 to 40)	0.59^{b}	0.61^{b}	0.61^{b}	0.60^{b}	0.64^{a}	0.60^{b}	0.13	P0.05

Blood profile

Compared with the control group, the serum ALP and SOD concentrations of piglets increased, but not significant (P>0.05), when Availa-Zn-170 was added in the diet (**Table 3**); and the concentration of serum Zn on day 14 and 40 increased when Availa-Zn-170 was added in the diet (P<0.05).

Table 3: *Diarrhea rate, %. ^{a,b}Within a row, means without a common superscript differ (P<0.05).*

Item	CON	Availa-Zn-20	Availa-Zn-40	Availa-Zn-60	Availa-Zn-80	Zinc sulphate-80	SEM	P-value
Phase 1 (d 0 to 14)	8.63^{b}	6.99^{b}	27.08^{a}	30.56^{a}	11.16^{b}	9.35^{b}	10.6	P0.05
Phase 2 (d 14 to 40)	3.97	3.24	9.93	4.58	4.77	7.81	4.8	0.071
Overall (d 0 to 40)	5.64^{b}	4.64^{b}	16.09^{a}	13.88^{a}	7.06^{b}	8.09^{b}	5.45	P0.05

Apparent total tract digestibility

On d 14, ATTD of CP in pigs fed 20 mg/kg Availa-Zn-170 diet was greater (P<0.05) than piglets fed the CON diets, but ATTD of gross energy was not affected by dietary treatments (**Table 4**). On day 40, no effects of treatments were observed on ATTD of CP or gross energy.

Table 4: *Effects of Availa-Zn170 on blood profile in weaned piglets[1]. ^{a,b}Within a row, means without a common superscript differ (P<0.05). [1]Each mean represents 6 pens of 2 pigs per pen. Dietary treatments were as follows: CON=control diet; Availa-Zn-20=control diet+20 mg/kg Availa-Zn170; Availa-Zn-40=control diet+40 mg/kg Availa-Zn170; Availa-Zn-60=control diet+60 mg/kg Availa-Zn170; Availa-Zn-80=control diet+80 mg/kg Availa-Zn170; Zinc sulphate-80=control diet+80 mg/kg feed grade zinc sulphate.*

	Item	CON	Availa-Zn-20	Availa-Zn-40	Availa-Zn-60	Availa-Zn-80	Zinc Sulphate-80	SEM	P-value

	d 0	22	22.62	21.62	24.34	19.5	25.41	4.75	0.31
Zn, μmol/l	d 14	21.82b	24.32a	23.57a	26.70a	24.23a	20.20b	4.07	P0.05
	d 40	23.86b	28.20a	28.91a	28.02a	32.18a	27.61a	3.9	P0.05
	d 0	236.1	249.17	240.6	272.48	230.6	232.52	38.36	0.51
ALP, μ/l	d 14	232.67	243.51	275.23	272.63	280.11	255.26	56.86	0.62
	d 40	245.55	284.54	273.35	254.57	279.63	253.57	52.38	0.66
	d 0	48.84	49.26	47.15	47.36	47.14	49.9	1.64	0.77
SOD, mmol/l	d 14	46.4	48.09	54.85	54.49	55.67	50.12	4.58	0.98
	d 40	46.06	49.19	59.76	58.68	60.65	50.43	7.46	0.88

Table 5: *Effects of Availa-Zn-170 on nutrient digestibility in weaned piglets*[1]. ***a,b*** *Within a row, means without a common superscript differ (P<0.05).* [1]*Each mean represents 6 pens of 3 pigs per pen. Dietary treatments were as follows: CON=control diet; Availa-Zn-20=control diet+20 mg/kg Availa-Zn-170; Availa-Zn-40=control diet+40 mg/kg Availa-Zn-170; Availa-Zn-60=control diet+60 mg/kg Availa-Zn-170; Availa-Zn-80=control diet+80 mg/kg Availa-Zn-170; Zinc sulphate-80=control diet+80 mg/kg feed grade zinc sulphate.*

Item		**CON**	**Availa-Zn-20**	**Availa-Zn-40**	**Availa-Zn-60**	**Availa-Zn-80**	**Zinc Sulphate-80**	**SEM**	**P-value**
	d 14	81.25b	86.26a	79.96b	80.98b	79.41b	79.28b	3.57	P0.05
ATTD of CP, %	d 40	93.26	93.25	92.35	92.72	93.63	93.5	1.16	0.52
	d 14	86.74	89.08	86.12	86.2	86.03	85.52	2.89	0.13
ATTD of gross energy, %	d 40	94.96	96.23	94.44	94.71	95.32	94.95	1.8	0.28

Discussion

Growth performance

In this study, our results showed that Availa-Zn-170 exerted marginal positive effects on growth performance of piglets from day 0 to 40 post-weaning and it could be used as a good organic zinc alternative to inorganic zinc in diets of weaned piglets. The addition of organic zinc to pig diets has been examined for decades, and it has been clearly demonstrated that the addition of organic zinc can improve the growth performance of early weaned piglets [4].

Traditionally zinc supplement in the diet for pigs mainly is inorganic zinc (such as zinc sulfate, Zinc oxide). The ions which dissociate from inorganic zinc in the digestive tract can easily bind with other compounds (such as phytic acid, oxalic acid, phosphate ion) and turn into insoluble salt that passes though digestive tract and expelled from the body via feces, thereby reducing the absorption of trace elements. Heugten et al. (2003) fed weaned piglets with corn soybean barley based diet that was supplemented with 80 mg/kg Zn (zinc sulfate and zinc methionine form) and showed that pigs fed zinc methionine had greater feed efficiency than those fed zinc sulphate [11]. In this study, piglets fed the 40 mg/kg Availa-Zn-170 diet had greater ADG in Phase 1, Availa-Zn-80 increased ADG of piglets in Phase 2, the greatest value was observed with the Availa-Zn-80 treatment group during the overall period. These results are in agreement with a study conducted by Chen et al. (2001), who reported that Zn-AAC can improved ADG and ADFI significantly and the ideal dose is Zn-Met 80 mg/kg. Availa-Zn-170 is a complex of zinc amino acid chelate and shown marginal positive effects on growth performance.

Diarrhea rate

In this study, during the Phase 1 (d 0 to 14) and the overall period (d 0 to 40), The Diarrhea rate of Availa-Zn-40 and Availa-Zn-60 were respectively higher than that of CON , which was higher than normal. This observation is not consistent with previous report (He Z. F.,1993). During the weaning period, weaned piglets depend on the immune system to maintain intestinal digestion and absorption function (Bailey and Haverson 2006). Ahn et al. (1998) added zinc methionine 200 mg/kg in the diet of piglets and reported increased concentration of IgG in serum of piglets [12].

Diarrhea of weaned piglets is a major issue to be solved in the production of piglets. Weaning stress increased villous atrophy and crypt cells of piglets, thereby reducing the ratio of villus height and crypt depth [13]. Poulsen (1989) reported for the first time that, adding 3000 mg/kg of Zinc oxide in the diet can reduce the incidence of diarrhea, improve growth performance of weaned piglets [14]. Therefore, people began to study the effect of high level of Zinc oxide on the diarrhea of early weaned piglets. Weaning stress often results in depressed feed intake, decreased growth performance and high diarrhea rate of piglets. High doses of Zinc oxide in the diet can increase feed intake, daily weight gain and reduce diarrhea rate of weaned piglets [15-17]. It is also reported that high zinc diets can improve growth performance and decrease the rate of diarrhea of weaned piglets, so the effect of 2500-3000 mg/kg Zinc oxide in weanling pig diets is often attributed to the regulation of high zinc on intestinal microbial flora [14,15,17].

Vahjen et al. (2012) studied the inhibitory action of 2 Zinc oxide sources on the ex vivo growth of small intestinal bacteria from weaned piglets [18]. Lag time was higher in media supplemented with a new Zinc oxide preparation in stomach samples. Katouli et al. (1999) reported Zinc oxide can increase the intestinal microbial stability, reduce the diversity of *Escherichia coli* but had no effect on the total number of *E.coli* [19]. Jensen et al. (1998) also reported no effect on the number of *Escherichia coli*, added 2500 mg/kg Zinc oxide in diets of weaned piglets had no effect on *Escherichia coli* and *Enterococcus* [17]. Castillo et al. (2008) studied that the addition of combination mannanoligosacharides (BM) and organic zinc could improve the efficiency of gain during the starter period, decreased *enterobacteria* counts and crypt depths in the jejunum [20].

In this study, the diarrhea rate of Availa-Zn-40 and Availa-Zn-60 were higher than that of control group, which was higher than normal. The reason for the high rate of diarrhea in weaned piglets mainly include the influence of weaning stress on intestinal tract, may also be related to the diet without high doses of Zinc oxide. Weaning stress increased villous atrophy and crypt cells of piglets, thereby reducing the ratio of villus height and crypt depth [13].

Blood profile

Our results revealed that absorption and utilization-related blood profile (Zn, ALP and SOD) were affected by the Availa-Zn-170 supplementation. The ALP and SOD concentrations had a trend to increase throughout the experimental period, the concentration of serum Zn on d 14 and 40 was increased when Availa-Zn-170 was added in the diet. The level of serum zinc of the body can reflect the absorption and utilization of zinc. Blood profile can reflect tissue osmotic pressure and body metabolism situation. Alkaline phosphatase reflected the growth of the animals. Zinc is a cofactor of ALP, which can catalyze hydrolysis of phosphate esters, so alkaline can be activated by the zinc content of the body. When the zinc content of the body is lower than the normal of the zinc content of the body, the activity of alkaline phosphatase would decline [21]. Therefore, in a certain extent, the level of serum zinc can reflect the absorption and utilization of zinc. When the zinc concentration of the body of the piglets decreased, which can be improved by added zinc in dietary, and the organic zinc was more effective than inorganic zinc.

Cu-Zn SOD is a zinc-dependent enzyme, which is very important for antioxidant defense system. Cheng and Guo (2004) reported that adding zinc amino acid could significantly increase total antioxidant capacity (T-AOC) and glutathione (GSH) content and decreased lipid peroxidation product malondialdehyde (MDA) formation in liver; it also significantly increased the activity of SOD and GSH and decreased malondialdehyde (MDA) levels in spleen of the 45-week-old laying hens. These results are consistent with the results of the present experiment which showed that adding different doses of organic zinc could improve the antioxidant capacity of the body. Therefore, zinc amino acid may be an important nutritional additive to maintain the antioxidant system.

Apparent total tract digestibility

In this study, ATTD of CP in pigs fed 20 mg/kg Availa-Zn-170 diet was greater than pigs fed the CON diets on d 14, only a tendency of increasing ATTD of DE on 14 and 40, ATTD of CP on 40. It has reported in previous study that positive effects of organic Zn chelation strength on the bioavailability. Huang et al. (2009) indicated that MT mRNA concentration in pancreas was more sensitive in reflecting differences in bioavailability among organic Zn sources than the MT concentration in pancreas or other indices [22]. Moreover, the bioavailability of organic Zn sources was closely related to their chelation strength. This is consistent with the results of this experiment.

Amino acid and peptide chelate is the main form of the body's absorption of metal ions, and is the intermediate material of animal protein synthesis in the process and therefore, can reduce the number of biochemical process, saves the energy consumption, the biological value has higher. When trace elements and amino acids are chelated into compounds, its efficiency of absorption and utilization is improved(AAFCO2001). The formation of related enzymes involved in the formation of hormones, which improve the efficiency of nutrients digestion and metabolism. Availa-Zn-170 could increase the apparent total tract digestibility of CP and DE, and has shown positive effect on growth performance in weaned piglets. However, previous study indicated that, trace element amino acid chelate (AATMC) could utilize amino acids and small peptides absorption channel, and come into plasma via the intestinal mucosa [23]. As a result, trace element amino acid chelate was very effectively absorbed and transported to the target organ and the biological utilization rate was high.

The pancreas plays an important role in zinc homeostasis. Zinc is involved in both exocrine and endocrine functions of pancreas including insulin production, secretion and signaling. The current study revealed a higher activity of digestive enzymes lipase, trypsin, chymotrypsin, α-amylase in pancreas tissue of pigs fed HZn diets. This is in good agreement with previous findings in pigs and rats. It has been proposed that excess dietary zinc affects mainly the pancreatic enzyme synthesis in pigs but not enzyme secretion.

In conclusion, results of this study indicated that Availa-Zn-170 could be an effective alternative to inorganic zinc to increase growth performance in weaned piglets through increasing nutrients digestion and metabolism, such as ATTD of CP, the concentration of Zn. On the basis of the current study, Availa-Zn-170 would be most effective in improving growth performance of weaned piglets, when supplemented 40 mg/kg Availa-Zn-170 from 21 to 35 d old, 80 mg/kg Availa-

Zn-170 from 35 to 60 d old. In particular, the effect of Availa-Zn-170 for the early stage is better than that for the late stage.

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Correspondance to:

R. J. Fang

College of Animal Science and Technology

Hunan Agricultural University

Changsha

PR. China