ARCHIVOS LATINO AMERICANOS DE NUTRICIÓN
Órgano Oficial de la Sociedad Latinoamericana de Nutrición
Vol. 70 N°3 (2020) pp. 535-542

Valor nutricional y medición matemática de oligoelementos orgánicos

Nutritional Value and Mathematical Measurement of Organic Trace Elements

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Resumen
La estabilidad bioquímica de los oligoelementos orgánicos tiene un efecto protector sobre los iones metálicos e inhibe eficazmente la interacción mutua de los elementos minerales. Complejos de oligoelementos orgánicos o quelatos de oligoelementos formados con aminoácidos, polisacáridos, péptidos y proteínas como ligandos, como el quelato de metionina de zinc, el quelato de lisina de hierro, la caseína de cobre y los complejos metálicos de polisacárido Espere. Este artículo analiza la nutrición de la salud y la medición matemática de oligoelementos orgánicos. La tasa de complejación de oligoelementos orgánicos, es decir, la proporción de elementos complejados, a menudo se usa como un indicador importante de la calidad del producto. La cromatografía de filtración en gel proporciona un método para separar sustancias separadas en tamaños moleculares basado en el principio de tamices moleculares. Los iones de elementos traza en estado libre pueden fluir debido a su bajo peso molecular, que puede separar elementos traza en diferentes formas. Se recogió el eluato del complejo de oligoelementos y se calculó la tasa de quelación. Con el objetivo de las características de varios oligoelementos orgánicos, el establecimiento de métodos de medición simples y efectivos es de gran importancia para la gestión de producción en fábrica y la supervisión del mercado.

Palabras clave: oligoelementos orgánicos; Nutrición de la salud; Medición matemática Tasa de complejación (quelación)

Abstract
The biochemical stability of organic trace elements has a protective effect on metal ions and effectively inhibits the mutual interaction of mineral elements. Organic trace elements complexes or chelates of trace elements formed with amino acids, polysaccharides, peptides, and proteins as ligands, such as zinc methionine chelate, iron lysine chelate, copper casein, and polysaccharide metal complexes Wait. This article analyzes the health nutrition and mathematical measurement of organic trace elements. The complexation rate of organic trace elements, that is, the proportion of complexed elements, is often used as an important indicator of product quality. Gel filtration chromatography provides a method for separating separated substances into molecular sizes based on the principle of molecular sieves. Trace element ions in the free state can flow out due to their low molecular weight, which can separate trace elements in different forms. The eluate of the trace element complex was collected and the chelation rate was calculated. Aiming at the characteristics of various organic trace elements, the establishment of simple and effective measurement methods is of great significance to factory production management and market supervision.

Key words: Organic trace elements; Health nutrition; Mathematical measurement; Complexation (chelation) rate

1. Introduction

For half a century, trace element additives have gone through three development stages: 1) inorganic salt additives, such as ferrous sulfate, copper carbonate and zinc oxide. 2) Some simple organic acid salts, such as ferrous citrate, zinc fumarate and chromium nicotinate. 3) Trace element complexes or chelates formed using amino acids, polysaccharides, peptides, and proteins as ligands, such as zinc methionine chelate, iron lysine chelate, copper casein, and polysaccharide metal complexes, etc [1]. Foreign countries have been studying organic trace elements since the 1960s, and China has been studying organic trace elements since the mid-1980s. In recent years, the research and application of organic trace elements in animal nutrition have received widespread attention, but people have different definitions of organic trace elements, and there are some inconsistent test results in the application of animal nutrition.

Piglet health management has always been a difficulty in restricting the improvement of pig breeding efficiency. The threats and challenges encountered by piglets in pig production are, in the final analysis, the two cores of piglet health management: intestinal health and "immunity". Piglets' "diarrhea" and "poor fur

appearance" are the most direct external manifestations of poor piglet health management [2]. The underlying substance means that piglets have low immunity and poor disease resistance.

In response to this problem, this article explores the effects of different organic trace elements on the health of piglets, analyzes the health of organic trace elements, and provides a reference for breeding practitioners. In addition, the mathematical determination of organic trace elements has important theoretical and practical significance for animal nutrition research, preparation of organic trace elements, livestock production, and market supervision [3]. This article will discuss the mathematical determination methods of organic trace elements in order to provide theoretical basis and methodological guidance for the scientific and effective application of organic trace element additives in animal husbandry production.

2. Concept and Biological Characteristics of Organic Trace Elements

The American Committee of Feed Management Officials (AAFCO, 2001) defines organic trace elements as: 1) metal protein salt: a product formed by the complexation of soluble metal salts with amino acids and partially hydrolyzed proteins. 2) Metal polysaccharide complex: a product formed by complexing a soluble metal salt with a polysaccharide solution. 3) Metal amino acid chelate: Metal ions in a soluble metal salt are covalently bonded to 1 to 3 mol (preferably 2 mol) of amino acid with 1 mol of metal [4-5]. The average relative molecular weight of the hydrolyzed amino acid is about 150, and the relative molecular weight of the formed chelate does not exceed 800. 4) Metal amino acid complex: a complex product formed by a soluble metal salt and one or several amino acids. 5) Metal (specific amino acid) complex: a complex reaction between a soluble metal salt and a specific amino acid [6].

The European Union has not clearly put forward the concept of organic trace elements. The Official Journal of the European Communities (OJEC) (1998) defines metal (iron, copper, manganese, and zinc) amino acid chelates as: the molecular formula is M (x) 1- 3.nH20, where M is a metal and x is a soybean protein After hydrolysis, the relative molecular mass of the final formed chelate does not exceed 1,500. The European Commission issued (EC) No479 / 2006 regulation on March 23, 2006, allowing the use of synthetic glycine as chelating ligands for chelated iron, copper, manganese and zinc. Currently the EU only allows hydrolysis of soy protein amino acids and synthetic glycine as chelating ligands for metal amino acid chelates [7].

There is no official definition of organic trace elements in China, and it is found in the literature reviewed by the author that people have different definitions of organic trace elements. Li Sufen (2003) believes that organic trace elements are the general term for products formed by inorganic salts of trace elements and organic ligands. Tong Shengyao (2003) pointed out that organic trace elements can be divided into metal complexes (ligand compounds) and chelate compounds [8-9]. Complexing agents include natural organic substances such as proteins, amino acids, sugars, and organic acids. Some people think that organic trace elements are the second and third generation trace element additives after inorganic mineral salts, and most of them can be divided into coordination compounds and protein conjugates.

The biochemical stability of organic trace elements has a protective effect on metal ions, effectively inhibits the mutual interaction of mineral elements, reduces the destruction of vitamins by metal ion redox reactions, thereby reducing the loss of nutrients and improving its biology value [10]. After the inorganic trace elements dissociate into ionic state in the intestine, most of them are combined with organic substances (from diet or endogenous secretion) in the intestine, including amino acids, phytic acid and various organic acids to form organic complexes and are excreted [11]. Organic trace elements with suitable complex stability may exist in the intestinal contents in the form of organic complexes, and do not interact with other substances in the intestine.

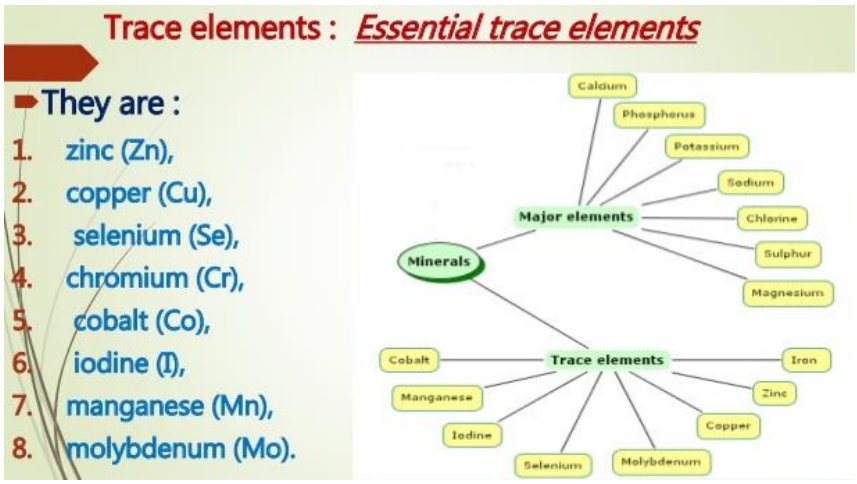

Figure 1. Trace Element

After the ionic trace elements reach the intestinal mucosa, they mainly enter the intestinal cells through the carrier-mediated active transport. High concentrations of trace elements can also enter the intestinal cells through easy diffusion [12]. There are two kinds of hypotheses about the absorption mechanism of organic trace elements: one view (Miller, cited by Ash-mead, 1993a) believes that trace element amino acid complexes or chelates can be absorbed more effectively because the degree of complexation is appropriate After the organic trace elements enter the digestive tract, it can prevent metal elements from being precipitated or adsorbed in the intestine by factors or other influencing factors, and directly reach the brush-shaped margin of the small intestinal mucosa, and hydrolysis occurs at the absorption site, where the metal enters the intestine in the form of ions. Epithelial cells are absorbed into the blood, which results in an increase in the amount of trace elements entering the body. This viewpoint emphasizes that the presence of organic trace elements in the digestive tract and the amount of them reaching the absorption site of the small intestine are more than the inorganic form [13]. Another view (Ashmead, 1993b) holds that metal amino acid complexes or chelates are completely absorbed using peptide or amino acid absorption mechanisms, and have different absorption pathways than inorganic salts. The core of this view is that metal ions are bonded to the ligands of amino acids or small peptides by covalent bonds and ionic bonds, are protected at the core of the chelate or complex, and pass through the mucosal cell membrane and mucosal cells as a whole. And basal cell membranes enter the blood [14]. However, due to the lack of effective detection methods for chelated or complexed elements, and research methods for the instability of the digestive tract in animals, the pH of the intestinal cavity, and factor etc., it makes comparison of the absorption mechanism of organic trace elements. Difficult [15]. There is no direct experimental evidence to confirm that trace element complexes or chelates are absorbed as a whole through the absorption mechanism of amino acids or peptides.

2.1 Mathematical Model of T> MIC Repeatedly Repeatedly Dose Repeatedly at Constant Dose and Interval

Repeated administration is actually a combination of multiple single-dose administrations, and the drug-time curve of multiple-dose administrations is also a superposition of the drug-time curves of multiple single-dose administrations. For single-compartment, single-dose intravenous infusion administration can be expressed by the following formula.

$$f\ (t, C) = \frac{\mathrm{K0}\ (1-e^{-kt})}{\mathrm{KVd}} (0 \le t \le t) \qquad (1)$$

$$f\ (t, C) = \mathrm{C}_{\max} \times \mathrm{e}^{-\mathrm{Kt}}\ (t_{\mathrm{lose}} \le \mathrm{t} \le \infty) \qquad (2)$$

In the formula: C is the blood drug concentration; K0 is the zero-order drip rate (indicated by the amount of drug input per unit time); Vd is the apparent distribution volume; K is the elimination rate constant; Cmax is the peak drug concentration; t_{lose} for drip time).

Formulas (1) and (2) respectively reflect the variation of C with t during and after a single-dose constant-speed intravenous drip. Assuming that the drug is delivered at a constant rate during t-transfusion, substituting (t1, MIC) and (t-transport, Cmax) into formula (1) can respectively find the time t1 when the blood concentration first reaches MIC after a single dose, and at The blood concentration Cmax at the end of the injection; substituting (t2, MIC) into formula (2) can find the time taken for the blood concentration to decrease from Cmax to MIC. Then T> MIC = t-t1 + t2. For the nth single-dose administration, as long as the (Cmax) n of the curve at the time of this drug is known, (Cmax) n can be calculated by formula (2), and the time to decrease to MIC (t2) n, Residual blood concentration (Cmin) t-1 after the first dose (existed after the second dose), the time to reach the MIC after the nth dose will be advanced, and the time to reach the MIC is (t1) n , Then (t1) n can be calculated from MIC- (Cmin) n-1 = $K_0(1-e^{-Kt'})/(K \times V_d)$, and (Cmin) n-1 can be calculated from (Cmax) n-1 =$\times e^{-Kt''}$ (t, τ at this time, the dosing interval). Therefore, T> MIC in any one drug curve can be obtained. (Cmax) n after the nth single-dose administration (that is, the n-th drug-time curve formed), the residual blood drug concentration (Cmin) n when the T interval is reached, and the lower branch of the curve are arbitrary The mathematical expression of blood concentration Cn and T> MIC in the curve at the time point is as follows.

The first drug time curve formed after the first drug:

$(C_{max})\ 1 = (C_{max})\ 1$

$(C_{min})\ 1 = (C_{max})\ 1\, e^{-K\tau}$

After τ , the second drug time curve formed after the second drug:

$(C_{max})2=(C_{max})1(1+e^{-kt})$

$(C_{max})2=(C_{max})1(1+e^{-kt})$ which is $(C_{max})1(e^{-kt}+ e^{-2kt})$

After τ , the third drug time curve formed after the third drug:

$(C_{max})3=(C_{max})1(1+e^{-kt}+ e^{-2kt})$

$(C_{max})3=(C_{max})1(1+e^{-kt}+ e^{-2kt})\ e^{-kt}$ which is $(C_{max})1(e^{-kt}+ e^{-2kt}+e^{-3k})$

After (n-1) τ , the n-th drug time curve formed after the n-th drug:
$(C_{max})n=(C_{max})1(1+e^{-kt}+ e^{-2kt}+ e^{-3k}\ldots\ldots+e^{-(n-1)kt})$
$(C_{min})n=(C_{max})1(1+e^{-kt}+ e^{-2kt}+ e^{-3k}\ldots\ldots+e^{-(n-1)kt})e^{-kt}$
Which is $(C_{max})1(1+e^{-kt}+ e^{-2kt}+ e^{-3k}\ldots\ldots+e^{-(n-1)kt}+ e^{-nkt})$
Set up $r=(1+e^{-kt}+ e^{-2kt}+ e^{-3k}\ldots\ldots+e^{-(n-1)kt})$
Then $r\,e^{-kt}= e^{-kt}+ e^{-2kt}+ e^{-3k}\ldots\ldots+e^{-(n-1)kt}+ e^{-nkt}$
Get $r=(1- e^{-nkt})/(1- e^{-kt})$
Therefore, the (Cmin) and (Cmax) of the n-th drug time curve can be changed to:

$$(C_{\max})_n = (C_{\max})_1(1-e^{-nK\tau})/(1-e^{-K\tau})$$

$$(C_{\min})_n = (C_{\max})_1(1-e^{-nK\tau})\ e^{-K\tau}/(1-e^{-K\tau})$$

The mathematical expression of T> mic in the curve at the n-th drug time is derived as follows:
Within the curve of the first drug:
$(t_1)_1$can be obtained from $MIC=K_0(1- e^{-kt})/(K\times V_d)$
$(t_2)_2$ can be determined by $MIC=(C_{max})\ 1\times e^{-kt}$
Calculated
(T>MIC)1 is :$t_{lose}+ln\frac{\mathrm{MICK_0}}{(\mathrm{Cmax})1(K_0+\mathrm{MICKV}_d)}/-K$
Within the second dose curve:
$(t_1)_2$ can be obtained from $MIC-(C_{min})1=K_0(1- e^{-kt})/(K\times V_d)$, that is, $MIC-(C_{max})1e^{-kt}=K_0(1- e^{-kt})/(K\times V_d)$
$(t_2)_2$ can be obtained from $MIC=(C_{max})\times(1- e^{-nkt})\ e^{-kt}/(1- e^{-nkt})(n=2)$, Calculated, $(T>MIC)_2$ is

$$t_{lose}+ln\frac{\mathrm{MICK_0}}{(\mathrm{Cmax})(1-\ e^{-2kt})1\{(K_0+[\mathrm{MIC}-(\mathrm{Cmax})1e^{-kt}]KV_d)\}}/-K$$

Within the 3rd dose curve:
$(t_1)_3$ can be obtained from $MIC-(C_{min})_2\ K_0(1- e^{-kt})/(K\times V_d)$, that is, $MIC-(C_{max})1(1- e^{-2kt})\ e^{-kt}=K_0(1- e^{-kt})/(K\times V_d)$
$(t_2)_3$ can be obtained from $MIC=(C_{min})\times(1- e^{-nkt})\ e^{-kt}/(1- e^{-nkt})(n=3)$, Calculated, $(T>MIC)_3$ is

$$t_{lose}+ln\frac{MIC(1-e^{-kt})K_0}{(\mathrm{Cmax})(1-\ e^{-3kt})1\{(K_0-[\mathrm{MIC}-(\mathrm{Cmax})1(1-e^{-2kt})e^{2kt}]KV_d)\}}/-K$$

And so on, and finally
$(T_{>MIC})$n is

$$t_{lose}+ln\frac{MIC(1-e^{-kt})K_0}{(\mathrm{Cmax})(1-\ e^{-nkt})1\{(K_0-[\mathrm{MIC}-(\mathrm{Cmax})1(1-e^{-(n-1)kt})e^{2kt}]KV_d)\}}/1-e^{-kt}/-K$$

2.2 Comparison of T> MIC Simple Model and Monte Carlo Simulation

When performing Monte Carlo simulation (MCS) on the dosing regimen, first enter the MIC, pharmacokinetic data, and dosing regimen data; second, based on the PK / PD index, enter f% T> MIC or AUC / MIC Formula; third, make distribution assumptions on MIC and pharmacokinetic parameters [6]; fourth, set MCS operating parameters; finally, obtain the cumulative response score of the simulated drug regimen to a pathogenic microorganism. MCS actually simulates or infers the probability of a certain MIC flora reaching the target threshold by setting a target threshold of f% T> mic in advance. When the probability exceeds 90%, the solution is considered feasible. For time-dependent antimicrobials, the f% T> MIC formula most used in MCS to determine the dosing schedule is as follows.

$$f\%T_{>MIC}=\ln(\frac{Dose\times f}{V_d\times MIC})\times\frac{t_{1/2}}{0.693\times\tau}\times100\%$$

In the formula: f% T> MIC is the time when the concentration of free drug exceeds MIC; Dose is the 24h dose; f (f = 1-PBs) is the percentage of free drug; Vd is the apparent volume of distribution; t1 / 2 is the biological half-life ; τ is the dosing interval.

3. Analysis of Organic Trace Element Health Nutrition

3.1 Organic Trace Element Health Nutrition and Piglet Health

Achieving pig health management through nutrition has gradually gained widespread recognition and attention in the industry. With the deepening research on the relationship between nutrition and pig health, people have gradually realized that in addition to the basic nutritional effects of major nutrients, they also have more important health nutritional effects. For example, many essential amino acids (methionine, threonine, etc.) are metabolized into intermediate products involved in the regulation of intestinal function, used for intestinal mucosal synthesis and to maintain the intestinal mucosal barrier. Mao et al. Reported that the increase of

threonine level significantly relieved the intestinal damage caused by immune stress [16]. Methionine can be converted into cysteine or S-adenosylmethionine (for the synthesis of polyamines) and promote intestinal epithelium. Cell maturation and differentiation. In terms of trace element nutrition, most people's understanding is still only at the basic nutrition level, and they have not fully realized the health-care nutritional value of organic trace element nutrition which is vital to animal health [17]. A large number of studies have shown that the nutritional value of organic trace elements is important to improve the intestinal health of piglets (Table 1), improve immunity (Table 2), and achieve piglet health.

Table 1: Health Nutrition of Organic Trace Elements and Intestinal Health of Piglets

Organic trace elements	Health Nutrition and Intestinal Health of Piglets
Organic zinc	Decrease intestinal permeability and protect intestinal mucosal barrier: promote the expression of tight junction protein mRNA in intestinal epithelial cells and increase the expression of tight junction protein. Promote intestinal development, repair intestinal mucosa, and improve intestinal structure: increase the expression of insulin-like growth factor and its receptors and proteins in the small intestinal mucosa, repair damaged mucosa, promote intestinal villus development, and maintain the intestinal structure and function of piglets. Improve intestinal flora: inhibit the adhesion of harmful bacteria on the intestinal mucosa and prevent bacterial enteritis. Reduce inflammatory response caused by weaning stress: reduce the expression of genes and proteins of intestinal stem cell factors in weaned piglets, thereby affecting the release of histamine, reducing inflammatory cytokines, and reducing the incidence of diarrhea.
Organic copper	Promote intestinal development: increase the height of the small intestine villi and reduce the depth of the small intestine crypts. Improve intestinal flora: Inhibit the reproduction of harmful microorganisms in the intestine, and regulate the intestinal microecology.
Organic iron	Antioxidant and protect the intestinal tract: Antioxidant prevents the lipid peroxidation of intestinal tissues, which can cause inflammatory enteritis. Promote intestinal development: promote the development of intestinal villi and reduce the depth of small intestinal crypts.
Organic selenium and manganese	Antioxidant and protect the intestine: important components of peroxidase such as glutathione, can protect cell membrane and mitochondria membrane from lipid peroxidation, thus preventing and repairing intestinal mucosal damage.

Table 2: Trace Element Health Nutrition and Piglet Immunity

Organic trace elements	Health nutrition and piglet immunity
Organic zinc	Antioxidant, reduce stress damage: induce the production of zinc metallothionein (Zn-MT), as a structural component of copper zinc superoxide dismutase (Cu Zn-SOD), improve the antioxidant enzymes (Cu Zn-SOD, SOD, CAT, GSH-Px, etc.) activity and content.
Organic copper	Enhance immune function: promote the humoral immune response of piglets, increase the number of white blood cells and Ig G content, increase the content of blood immune factors and the expression of intestinal immune-related genes in piglets. Antioxidant, reduce stress damage: increase the activity and content of antioxidant enzymes such as copper zinc superoxide dismutase (Cu Zn-SOD), ceruloplasmin (CP) and corresponding mRNA expression, and maintain immune cell function.
Organic iron	Improve hematopoiesis and immune function: Promote hematopoiesis, increase hemoglobin content in piglet blood, increase T, B lymphocyte conversion rate, rosette formation rate, immune organ index and serum immunoglobulin content Antioxidant and reduce stress damage: The activity of antioxidant enzymes and GSH content of CAT, SOD, SDH, XOD, T-AOC, MDA in the blood of weaned piglets were increased.
Organic selenium and manganese	Improving immune level: increasing the content of immunoglobulins such as Ig A, Ig G, and Ig M in piglets serum, lymphocyte conversion rate, active rosette rate and total rosette rate increased Antioxidant, reduce stress damage: can increase the content of antioxidant enzymes such as GSH, GPx, SOD and CAT.

3.2 Nutritional Value Advantages and Selection of Organic Trace Elements

The nutritional value of organic trace elements can be divided into three levels: basic nutrition, functional nutrition, and health nutrition [18]. At present, the trace elements used in feed are mainly divided into two categories, one is inorganic trace elements mainly based on sulfate, and the other is organic trace elements mainly based on amino acid complexes (chelates). Process differences, the two have significant differences in physical and chemical properties and nutritional value, as shown in Table 3.

While organic trace elements can effectively meet the basic nutritional needs of animals, they can give full play to the nutritional value of trace elements. Common types of organic trace elements are: organic acid salts, glycine complexes, hydrolyzed protein salts, hydroxymethionine chelate, threonine chelate, etc. There are also large differences in physical and chemical properties and nutritional values between them, as shown in Table 4.

It can be seen from Table 4 that organic trace elements such as hydroxymethionine / threonine chelate are the representative types that can best exert the nutritional value of trace elements [19].

Table 3: Nutritional Value Comparison of Inorganic and Organic Trace Elements

Item	Inorganic trace elements	Organic trace elements
safety	Risk of exceeding toxic and hazardous substances such as heavy metals, oxidants, dioxins and PCBs.	Low content of toxic and harmful substances and impurities, reducing safety risks caused by residues.
Stability	Easy to absorb moisture and agglomerate, which can damage vitamins and other nutrients.	Good stability, not easy to absorb moisture and cake, less damage to vitamins and other nutrients.
Synergistic antagonism	Absorption in ionic form, there is competition for absorption, it is easy to antagonize with other mineral elements, phytic acid, etc.	Completely absorbed by the amino acid route, without absorption antagonists, and does not antagonize with other ingredients in the feed.
Effectiveness	Poor palatability, low absorption and utilization, mainly meet basic nutritional needs.	Good palatability, high absorption and utilization, functional nutritional value and health nutritional value.

Table 4: Comparison of Nutritional Value of Different Organic Trace Elements

Project	Hydroxymethionine / threonine chelate	Hydrolyzed protein salt	Glycine complex (chelate)	Organic acid salt
Ingredients	Single and clear composition	Complex raw materials and unclear composition	Single and clear composition	Single and clear composition
Detectable	Detectable	Difficult to detect	Detectable	Detectable
Nutritional value	Essential amino acids are used as ligands to give full play to health and functional nutrition	Complex composition, unstable effect, and functional nutrition	Non-essential amino acids as ligands, with some functional nutrition	Easy to dissociate, low absorption and utilization rate, nutritional value is equivalent to ordinary inorganic salt

Figure 2. Trace Element (Chelate) Complex

4. Determination Method for Chelating Rate of Organic Trace Elements

The complexation (chelation) ratio of organic trace elements, that is, the ratio of complexed (chelated) elements, is often used as an important indicator of product quality. For an organic trace element additive product, its chelation will be given accordingly Rate, combined with other measured data, provides comprehensive information about the product [20]. For example, Lin Namei and others used copper acetate and glycine as raw materials to synthesize copper monohydrate monohydrate using a one-step solid-phase reaction at room temperature. The chelation rate of the obtained product was 98.27%. Li Daguang et al. Used zinc chloride and glycine as raw materials and synthesized zinc glycine monohydrate in a one-step solid-phase reaction at room temperature. The chelation rate of the product reached 94.39%. Yang Yunshang et al. Synthesized L-aspartic acid zinc chelates using L-aspartic acid and zinc nitrate as raw materials [21]. The chelation rate was 95.2%. Yang Lin et al. Determined that the chelation rates of iron, copper, zinc, and manganese were 95.6%, 99.3%, 98.2%, and 95.6%, respectively. Yao Lei et al. Used ferrous sulfate and L-glycine as raw materials to synthesize a chelate rate of 65.43%.

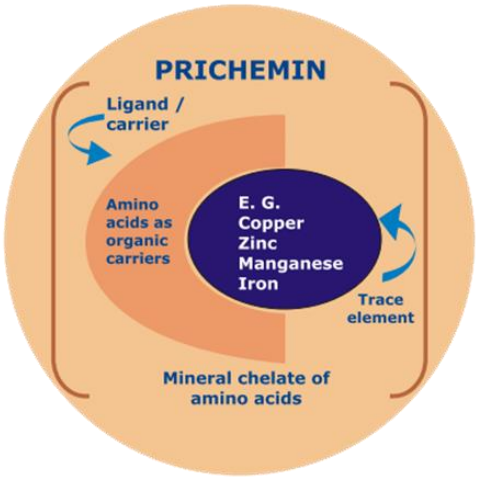

Figure 3. Organic Trace Element Chelation

4.1 Gel Filtration Chromatography

4.1.1 Biogel P-2

Gel filtration chromatography refers to the method of Brown et al. Gel filtration chromatography provides a method that can separate the separated substances according to the molecular size according to the principle of molecular sieve. After the organic trace element solution passes through the gel chromatography column, Trace element complexes flow out of the column first due to their high molecular weight, while trace element ions in the free state flow out later due to their low molecular weight, which can separate trace elements in different forms. The eluate of the trace element complex was collected and the chelation rate was calculated.

4.1.2 Dextran Gel Filtration Chromatography

Based on GB / T 13080.2-2005 Dextran Gel Filtration Chromatography to determine the chelation rate principle: Organic trace element complex (chelate) samples are dissolved by heating, centrifuged, and separated into precipitated chelating elements, soluble chelating elements Free metal ions. Soluble chelating elements and free metal ions are eluted under prescribed conditions by gel chromatography to separate the soluble chelating metal elements and free metal ions. Atomic absorption spectrometry is used to determine the precipitation chelating elements and soluble chelation, respectively. The content of element and free metal ion can calculate the chelation rate of the corresponding chelate.

4.2 Organic Solvent Extraction

Organic solvent extraction method utilizes the solubility of organic trace element complexes (chelates) in organic solvents, and the free inorganic metal ions can be dissolved in organic solvents such as methanol and ethanol. The free state can be separated by organic solvent extraction. Metal ion. After separation, the content of trace elements can be measured by complexometric titration and redox titration to calculate the chelation rate.

5. Conclusion

Organic trace elements are good for promoting the growth and development of animals, reducing feeding costs, and reducing environmental pollution. Aiming at the characteristics of various organic trace elements, the establishment of simple and effective measurement methods is of great significance to factory production management and market supervision.

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