

USE OF A CLASS OF ORGANIC ACID METAL COMPOUNDS AS ANIMAL FEED ADDITIVES

5 Technical Field

[0001] The present invention relates to the field of animal feed additives, and in particular to the use of a class of organic acid metal compounds and/or solvates thereof as animal feed additives or in the preparation of animal feed additives.

10 Background Art

[0002] Organic Al compounds are of great variety and are widely used, and common organic Al compounds comprise Al formate compounds and Al acetate compounds. Al formate compounds are often used as catalysts in organic synthesis reactions, particularly in esterification reactions, which can promote the formation of esters and increase the reaction rate and yield, such as the synthesis of amino acid esters. As a wood preservative, Al formate compounds can protect wood from fungi, insects and other organisms, and prolong the service life of wood by penetrating the surface and binding to fibers in the wood to form a protective film. Al formate compounds can be used as an ingredient of certain dyes and pigments, and can also be added to paper pulp as a paper strengthening agent. Al acetate compounds have antibacterial, anti-inflammatory and antipruritic effects. As early as the early 20th century, Al acetate compounds were used as preservatives, astringents and antipyretics in the technical fields such as medicine and dyes. Al acetate compounds can also be used as catalysts and color fixing agents in leather dyeing and tanning processes.

[0003] In addition to this, disclosed are organic Al compounds that can be used in the preparation of polyurethane foams, or as anti-caking agents, stabilizers or viscosity control agents in liquid foundations, sunscreens and moisturizing creams, or as nucleating agents and surfactants for plastic processing, or as one of the ingredients of a defoaming agent, or as one of the ingredients of a conductor paste in the preparation of an electrode of a chip resistor, or as one of the ingredients of a grease composition, or as catalyst compositions for polyesters. However, there is no report on the use of organic acid Al compounds in the feed industry and the field of animal farming.

Summary of the Invention

[0004] On this basis, the present invention provides the use of a class of organic acid metal compounds and/or solvates thereof as animal feed additives or in the preparation of animal feed additives, and further provides a composition comprising the organic acid metal compounds and/or the solvates thereof.

[0005] In order to achieve the above-mentioned object of the present invention, the present invention provides the use of an organic acid metal compound having a molecular

formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or a solvate thereof as an animal feed additive or in the preparation of an animal feed additive:

5 [0006] wherein n is any natural number; R^1 is selected from Y-C(O)O- or a plant polyphenol, and each of R^2 and R^3 is independently selected from -OH, Y-C(O)O- or a plant polyphenol;

[0007] Y is selected from H, linear or branched C_1 - C_{19} alkyl or linear or branched C_1 - C_{19} alkyl substituted with 1-5 R^4 , C_3 - C_7 cycloalkyl or C_3 - C_7 cycloalkyl substituted with 1-5 R^4 , C_3 - C_7 cycloheteroalkyl or C_3 - C_7 cycloheteroalkyl substituted with 1-5 R^4 , C_5 - C_{12} aryl or C_5 - C_{12} aryl substituted with 1-5 R^5 , C_5 - C_{12} heteroaryl or C_5 - C_{12} heteroaryl substituted with 1-5 R^5 , $-(CH=CH)_m-(C_5-C_{12}$ aryl) or $-(CH=CH)_m-(C_5-C_{12}$ aryl) in which the C_5 - C_{12} aryl is substituted with 1-5 R^5 , $-(CH=CH)_m-(C_5-C_{12}$ heteroaryl) or $-(CH=CH)_m-(C_5-C_{12}$ heteroaryl) in which the C_5 - C_{12} heteroaryl is substituted with 1-5 R^5 ;

[0008] m is any natural number;

15 [0009] R^4 is -OH, -NH₂, -CN, -SH or -X₁, wherein X₁ is selected from F, Cl, Br or I;

[0010] and R^5 is -OH, -NH₂, -NO₂, -CN, -SH, -X₂, -C₁-C₅ alkoxy, -C₁-C₅ alkyl, or X₂-substituted -C₁-C₅ alkyl, wherein X₂ is selected from F, Cl, Br or I.

20 [0011] The present invention further provides a composition, which comprises an organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or a solvate thereof; preferably, the organic acid metal compound and/or the solvate thereof is an active component.

[0012] The present invention further provides the use of an organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or a solvate thereof as an animal feed additive or in the preparation of an animal feed additive, wherein preferably, the animal feed additive is an animal growth promoter.

25 [0013] The present invention provides a method for improving production performance of an animal, wherein the method comprises applying to the animal an organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or a solvate thereof or a composition comprising an organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or a solvate thereof.

30 [0014] In the present invention, it is confirmed through animal farming experiments that the organic acid metal compound and/or the solvate thereof provided in the present invention can effectively make animals gain weight and increase feed conversion rate, and has a good effect on improving production performance of animals; and more notably, 35 the organic acid metal compound and/or the solvate thereof provided in the present invention are essentially residue-free in the tissues such as muscles and liver of edible animals, and the content of element aluminum is below the instrumental detection limit of detection institutions for element aluminum or below the content of element aluminum in commercially available meat products or below the content of element aluminum in the meat of edible animals in a blank control group without receiving organic acid metal compounds, in accordance with the aluminum residue requirements specified in the food additive usage standard GB 2760-2014 [the residual amount of aluminum $\leq$ 100 mg/kg (equivalent to 100 ppm), (dry sample, in terms of Al)]. 40

[0015] Any embodiment according to any aspect of the present invention can be combined with other embodiments, unless they are contradictory to each other. In addition, in any embodiment according to any aspect of the present invention, any technical feature can be applied to the technical feature in other embodiments, unless they are contradictory to each other.

[0016] The foregoing content is merely a summary of certain aspects of the present invention, but is not limited to these aspects. The content involved above and in other aspects will be described more specifically and completely below.

10 Detailed Description of the Invention

[0017] The following detailed description is intended to enable those skilled in the art to implement different embodiments. Specific devices, techniques or applications are described by way of example only. The present invention intends to cover all alternative, modified and equivalent technical solutions, which are all included within the scope of the present invention as defined by the claims. Additionally, for clarity, some technical features of the present invention are described in multiple independent embodiments, respectively, but they may also be provided in combination or in the form of any suitable sub-combination in a single embodiment.

Organic acid metal compounds involved in the present invention

[0018] The present invention relates to a class of organic acid metal compounds having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or solvates thereof,

[0019] wherein n is any natural number; R^1 is selected from Y-C(O)O- or a plant polyphenol, and each of R^2 and R^3 is independently selected from -OH, Y-C(O)O- or a plant polyphenol;

[0020] Y is selected from H, linear or branched C₁-C₁₉ alkyl or linear or branched C₁-C₁₉ alkyl substituted with 1-5 R^4 , C₃-C₇ cycloalkyl or C₃-C₇ cycloalkyl substituted with 1-5 R^4 , C₃-C₇ cycloheteroalkyl or C₃-C₇ cycloheteroalkyl substituted with 1-5 R^4 , C₅-C₁₂ aryl or C₅-C₁₂ aryl substituted with 1-5 R^5 , C₅-C₁₂ heteroaryl or C₅-C₁₂ heteroaryl substituted with 1-5 R^5 , -(CH=CH)_m-(C₅-C₁₂ aryl) or -(CH=CH)_m-(C₅-C₁₂ aryl) in which the C₅-C₁₂ aryl is substituted with 1-5 R^5 , -(CH=CH)_m-(C₅-C₁₂ heteroaryl) or -(CH=CH)_m-(C₅-C₁₂ heteroaryl) in which the C₅-C₁₂ heteroaryl is substituted with 1-5 R^5 ;

[0021] m is any natural number;

[0022] R^4 is -OH, -NH₂, -CN, -SH or -X₁, wherein X₁ is selected from F, Cl, Br or I;

[0023] and R^5 is -OH, -NH₂, -NO₂, -CN, -SH, -X₂, -C₁-C₅ alkoxy, -C₁-C₅ alkyl, or X₂-substituted -C₁-C₅ alkyl, wherein X₂ is selected from F, Cl, Br or I.

[0024] In general, the "substituted" means that one or more than one replaceable hydrogen atoms in a given structure are replaced by the specific substituent groups. A substituted group can have a substituent at each substitutable position within the group, and when more than one position in a given structural formula can be substituted with one or more substituents of a specific substituent group, the substituent is either the same or different at each position.

[0025] In the present invention, the “C_a-C_b alkyl” means a linear or branched saturated alkyl group containing from a to b carbon atoms, such as methyl, ethyl, propyl and isopropyl, etc. For example, the “C₁-C₅ alkyl” means a linear or branched saturated alkyl group containing from 1 to 5 carbon atoms.

- 5 [0026] In the present invention, the “CH=CH” means a structural fragment -HC=CH- of an alkene, and the “(CH=CH)_m” means a conjugated alkene fragment consisting of m -HC=CH- units linked via single bonds.

- [0027] GB987715A, GB190708576A, GB190708643A and GB182446A disclose the processes for preparing an existing Al salt of an organic acid, and these processes and variations thereof can be used for preparing the aforementioned organic acid metal compounds, wherein when R² and R³ involved in the structure thereof are not OH, the R² and R³ can be the same as or different from R¹.

[0028] The physical form of the organic acid metal compound provided in the present invention can be a monomer or a polymer.

- 15 [0029] The monomer involved in the present invention indicates an organic acid metal compound having a molecular formula of Al(R¹)(R²)(R³).

[0030] The polymer involved in the present invention indicates an organic acid metal compound having a molecular formula of Al_n(R¹)_n(R²)_n(R³)_n, wherein n is a natural number greater than 2.

- 20 [0031] In some preparation schemes, reaction substrates having a multiple reactive functional groups may lead to reaction selectivity concerns during a reaction, resulting in that the product obtained by the preparation scheme of the above-mentioned organic acid metal compounds consists of one or more compounds having molecular formulas of Al_n(R¹)_n(OH)_n(OH)_n, Al_n(R¹)_n(R²)_n(OH)_n and Al_n(R¹)_n(R²)_n(R³)_n, wherein R¹ is selected from Y-C(O)O- or a plant polyphenol, and each of R² and R³ is independently selected from -OH, Y-C(O)O- or a plant polyphenol; and preferably, R¹, R² and R³ in this preparation scheme represent Y-C(O)O- or a plant polyphenol.

- [0032] The “plant polyphenol” involved in the present invention refers to a secondary metabolite having a polyphenolic structure which is derived from a natural plant, including but not limited to curcumin, grape polyphenol, ellagic acid, magnolol, an extract of Corni fructus, tea polyphenol, hydrolysable tannin, chestnut tannin, grapefruit tannin and tannic acid.

- 35 [0033] In some particular preparation schemes, the aforementioned product preferably consists of one or more compounds having a molecular formula of Al_n(R¹)_n(OH)_n(OH)_n, Al_n(R¹)_n(R¹)_n(OH)_n and Al_n(R¹)_n(R¹)_n(R¹)_n, wherein R¹, R² and R³ in this preparation scheme represent Y-C(O)O- or a plant polyphenol.

[0034] In some preparation schemes, the resulting product is an organic acid metal compound in which R¹ is selected from a plant polyphenol, and each of R² and R³ is independently selected from -OH or a plant polyphenol.

- 40 [0035] In some particular preparation schemes, the resulting product is an organic acid metal compound in which R¹ is selected from tannic acid, and each of R² and R³ is independently selected from -OH or tannic acid.

[0036] The “tannic acid” involved in the present invention refers to tannin obtained from *Galla chinensis*, also known as gallotannin, digallic acid, tannis or tannin.

[0037] In some preparation schemes, the resulting product is an organic acid metal compound in which R^1 is selected from $Y-C(O)O-$, and each of R^2 and R^3 is independently selected from $-OH$ or $Y-C(O)O-$, wherein Y is selected from linear or branched C_1-C_{15} alkyl or linear or branched C_1-C_{15} alkyl substituted with 1-5 R^4 , and R^4 is $-OH$, $-NH_2$, $-CN$, $-SH$ or $-X_1$, wherein X_1 is selected from F, Cl, Br or I.

[0038] In some embodiments, the resulting product is an organic acid metal compound in which R^1 is selected from $Y-C(O)O-$, and each of R^2 and R^3 is independently selected from $-OH$ or $Y-C(O)O-$, wherein Y is selected from C_4-C_5 cycloheteroalkyl or C_4-C_5 cycloheteroalkyl substituted with 1-5 R^4 , and R^4 is $-OH$, $-NH_2$, $-CN$, $-SH$ or $-X_1$, wherein X_1 is selected from F, Cl, Br or I.

[0039] In some embodiments, the resulting product is an organic acid metal compound in which R^1 is selected from $Y-C(O)O-$, and each of R^2 and R^3 is independently selected from $-OH$ or $Y-C(O)O-$, wherein Y is selected from phenyl or phenyl substituted with 1-5 R^5 , and R^5 is $-OH$, $-NH_2$, $-NO_2$, $-CN$, $-SH$, $-X_2$, $-C_1-C_5$ alkoxy, $-C_1-C_5$ alkyl, or X_2 -substituted $-C_1-C_5$ alkyl, wherein X_2 is selected from F, Cl, Br or I.

[0040] In some embodiments, the resulting product is an organic acid metal compound in which R^1 is selected from $Y-C(O)O-$, and each of R^2 and R^3 is independently selected from $-OH$ or $Y-C(O)O-$, wherein Y is selected from C_4-C_5 heteroaryl or C_4-C_5 heteroaryl substituted with 1-5 R^5 , wherein the heteroaryl contains O, S or N, and R^5 is $-OH$, $-NH_2$, $-NO_2$, $-CN$, $-SH$, $-X_2$, $-C_1-C_5$ alkoxy, $-C_1-C_5$ alkyl, or X_2 -substituted $-C_1-C_5$ alkyl, wherein X_2 is selected from F, Cl, Br or I.

[0041] In some embodiments, in the organic acid metal compound and/or the solvate thereof, Y is 3-pyridyl.

[0042] In some embodiments, in the organic acid metal compound and/or the solvate thereof, R^1 is selected from $Y-C(O)O-$, each of R^2 and R^3 is independently selected from $-OH$ and $Y-C(O)O-$, Y is selected from $-(CH=CH)_m$ -phenyl or $-(CH=CH)_m$ -phenyl in which the phenyl is substituted with 1-5 R^5 , m is any natural number, and R^5 is $-OH$, $-NH_2$, $-NO_2$, $-CN$, $-SH$, $-X_2$, $-C_1-C_5$ alkoxy, $-C_1-C_5$ alkyl, or X_2 -substituted $-C_1-C_5$ alkyl, wherein X_2 is selected from F, Cl, Br or I.

[0043] In some embodiments, in the organic acid metal compound and/or the solvate thereof, R^1 is selected from $Y-C(O)O-$, each of R^2 and R^3 is independently selected from $-OH$ and $Y-C(O)O-$, and Y is selected from $-(CH=CH)$ -phenyl.

[0044] In some embodiments, in the organic acid metal compound and/or the solvate thereof, the solvate of the organic acid metal compound is selected from one, more than one or a combination of a hydrate, an acetone solvate, an ethanol solvate, a methanol solvate, a dimethyl sulfoxide solvate, an ethyl acetate solvate, an acetic acid solvate, and/or an isopropanol solvate of the organic acid metal compound;

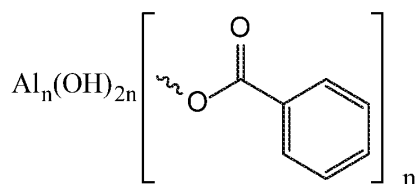
[0045] In some embodiments, the organic acid metal compound and/or the solvate thereof is selected from individual one or more organic acid metal compounds having the same or different molecular formulas, individual one or more solvates of organic acid metal compounds having the same or different molecular formulas, or a combination of one or more than one of organic acid metal compounds having the same or different

molecular formulas and one or more than one of solvates of organic acid metal compounds having the same or different molecular formulas.

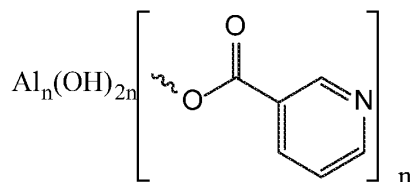
[0046] In some embodiments, the organic acid metal compound includes an organic acid metal compound monomer or an organic acid metal compound polymer.

- 5 **[0047]** In some of preparation examples, the organic acid metal compound is one of the compounds having molecular formulas as follows:

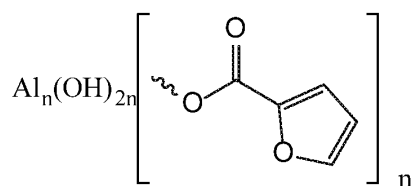
[0048] $\text{Al}_n(\text{OH})_{2n}(\text{CH}_3\text{COO})_n$ (abbreviated as “Al acetate”), $\text{Al}_n(\text{OH})_{2n}(\text{CH}_3(\text{CH}_2)_2\text{COO})_n$ (abbreviated as “Al butyrate”), $\text{Al}_n(\text{OH})_{2n}(\text{CH}_3(\text{CH}_2)_8\text{COO})_n$ (abbreviated as “Al caprate”), $\text{Al}_n(\text{OH})_{2n}(\text{CH}_3(\text{CH}_2)_{12}\text{COO})_n$ (abbreviated as “14Al”), $\text{Al}_n(\text{OH})_{2n}(\text{CH}_3(\text{CH}_2)_{14}\text{COO})_n$ (abbreviated as “Al palmate”),



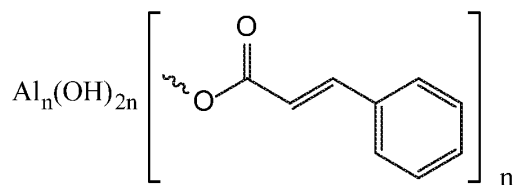
(abbreviated as “Al benzoate”),



(abbreviated as “NAI”),



(abbreviated as “KAl”), and



(abbreviated as “RAI”).

- 15 **[0049]** In some of preparation examples, the organic acid metal compound is one of the following combinations:

[0050] “Al acetate combination” is a combination of one or more than one of $\text{Al}_n(\text{OH})_{2n}(\text{CH}_3\text{COO})_n$, $\text{Al}_n(\text{OH})_n(\text{CH}_3\text{COO})_{2n}$ and $\text{Al}_n(\text{CH}_3\text{COO})_{3n}$;

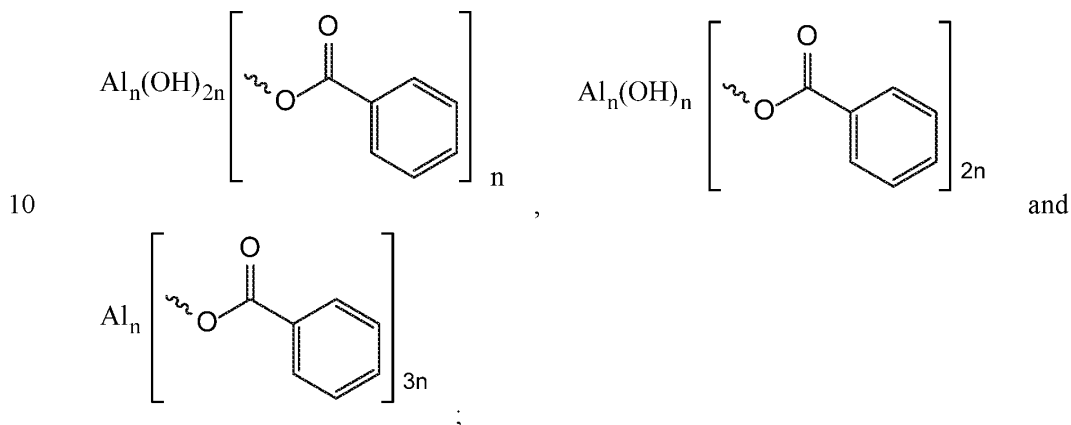
- 20 **[0051]** “Al butyrate combination” is a combination of one or more than one of $\text{Al}_n(\text{OH})_{2n}(\text{CH}_3(\text{CH}_2)_2\text{COO})_n$, $\text{Al}_n(\text{OH})_n(\text{CH}_3(\text{CH}_2)_2\text{COO})_{2n}$, and $\text{Al}_n(\text{CH}_3(\text{CH}_2)_2\text{COO})_{3n}$;

[0052] “Al caprate combination” is a combination of one or more than one of $\text{Al}_n(\text{OH})_{2n}(\text{CH}_3(\text{CH}_2)_8\text{COO})_n$, $\text{Al}_n(\text{OH})_n(\text{CH}_3(\text{CH}_2)_8\text{COO})_{2n}$ and $\text{Al}_n(\text{CH}_3(\text{CH}_2)_8\text{COO})_{3n}$;

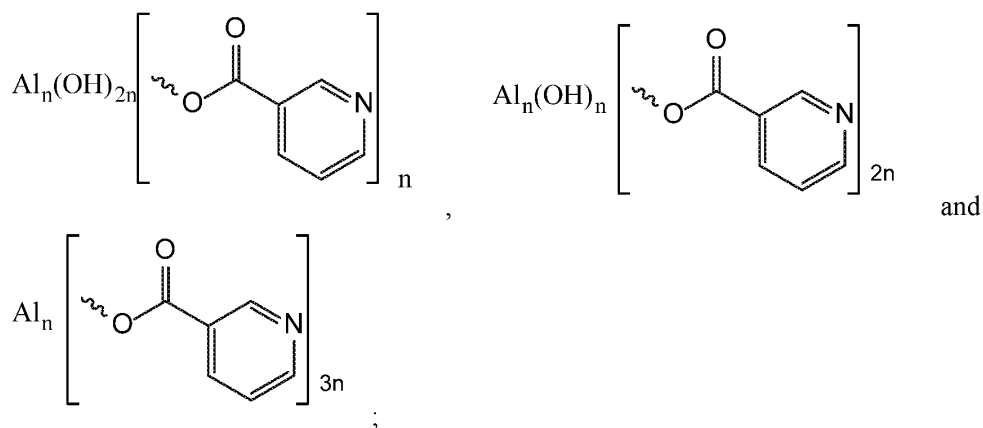
[0053] “14Al combination” is a combination of one or more than one of $\text{Al}_n(\text{OH})_{2n}(\text{CH}_3(\text{CH}_2)_{12}\text{COO})_n$, $\text{Al}_n(\text{OH})_n(\text{CH}_3(\text{CH}_2)_{12}\text{COO})_{2n}$ and $\text{Al}_n(\text{CH}_3(\text{CH}_2)_{12}\text{COO})_{3n}$;

[0054] “Al palmitate combination” is a combination of one or more than one of $\text{Al}_n(\text{OH})_{2n}(\text{CH}_3(\text{CH}_2)_{14}\text{COO})_n$, $\text{Al}_n(\text{OH})_n(\text{CH}_3(\text{CH}_2)_{14}\text{COO})_{2n}$ and $\text{Al}_n(\text{CH}_3(\text{CH}_2)_{14}\text{COO})_{3n}$;

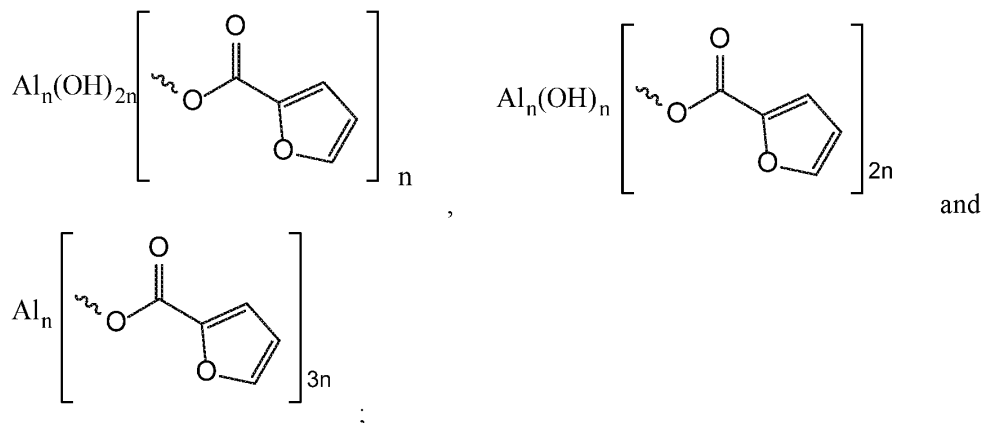
[0055] “Al benzoate combination” is a combination of one or more than one of



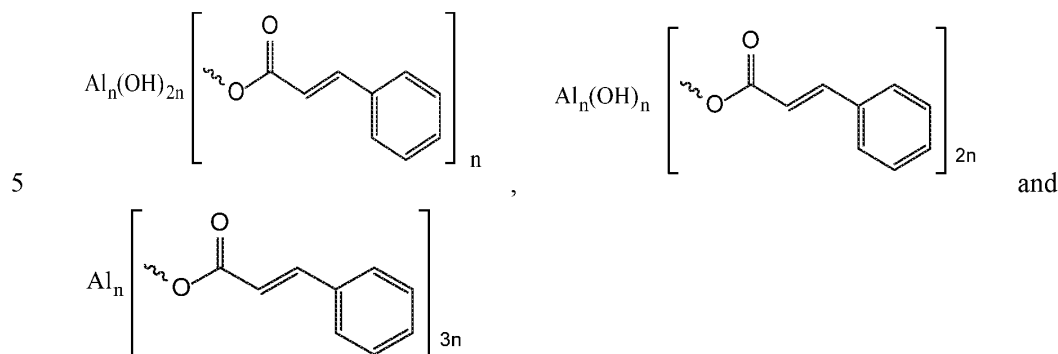
[0056] “NAl combination” is a combination of one or more than one of



[0057] “KAl combination” is a combination of one or more than one of



[0058] and “RAI combination” is a combination of one or more than one of



[0059] The “organic acid metal compound” involved in the present invention includes an organic acid metal compound monomer or an organic acid metal compound polymer, and also includes a combination of one or more organic acid metal compounds having the same or different molecular formulas.

[0060] In some embodiments, the preparation process of the organic acid metal compound further involves the separating, purifying or recrystallizing process of a reaction product. With regard to the reaction product, a crude product can be obtained from a reaction system through a desolvation method; and in order to obtain a solid substance having higher chemical purity and lower content of impurities, under suitable conditions such as suitable temperature, illumination and mechanical vibration, the crude product is dissolved, crystallized or precipitated or recrystallized in an alcohol solvent, an alcohol-water mixed solvent or other organic solvents that can be used for recrystallizing the product, and separated to obtain an organic acid metal compound having a certain material form.

[0061] The organic acid metal compound having a certain physical form is a solvate of the organic acid metal compound. The solvate of the organic acid metal compound can be selected from a hydrate, an acetone solvate, an ethanol solvate, a methanol solvate, a dimethyl sulfoxide solvate, an ethyl acetate solvate, an acetic acid solvate, or an isopropanol solvate of the organic acid metal compound.

5 [0062] The “solvate” involved in the present invention refers to a co-crystal association compound formed by the binding of stoichiometric or non-stoichiometric solvent molecules to the compound of the present invention through non-covalent intermolecular forces caused by external and internal conditions in the process of contacting the compound with the solvent molecules. Solvents for forming solvates include, but are not limited to, water, acetone, ethanol, methanol, dimethyl sulfoxide, ethyl acetate, acetic acid, isopropanol, etc. The “hydrate” refers to a complex or a crystal formed by water as a solvent molecule, i.e., a compound to which stoichiometric or non-stoichiometric water binds through non-covalent intermolecular forces.

10 [0063] The “organic acid metal compound and/or solvate thereof” involved in the present invention is selected from individual one or more organic acid metal compounds having the same or different molecular formulas, individual one or more solvates of organic acid metal compounds having the same or different molecular formulas, or a combination of one or more organic acid metal compounds having the same or different molecular formulas and one or more solvates of organic acid metal compounds having the same or different molecular formulas.

15 [0064] The experiments for studying the bioavailability of the organic acid metal compound provided in the present invention includes: an experiment for studying the effect of the organic acid metal compound and the solvate thereof on the growth performance of piglets, an experiment for studying the effect on the growth performance of broilers, an experiment for studying the effect on the production performance of laying hens, and an experiment for studying the application effect in feeds for meat duck. The research results show that the organic acid metal compound and the solvate thereof can effectively enhance / reduce / improve the growth rate, feed conversion rate, growth efficiency and growth of pigs, chickens and ducks in farming .

20 [0065] The present invention further studies the residual element Al in the muscles or tissues of broilers, meat ducks, pigs and laying hens when the organic acid metal compound and the solvate thereof is used in the feeds of the aforementioned animals. The results show that in a 3-6 month long-term feeding experiment, the residual content of element Al from the organic acid metal compound remaining in the body of the animals is lower than that in the blank control group or lower than the detection limit of instrument devices, which sufficiently indicates that the organic acid metal compound and the solvate thereof of the present invention can be used in feeds for broilers, meat ducks, pigs and laying hens, and have no residual element Al remaining in the muscles or tissues of the aforementioned animals.

Use of organic acid metal compounds involved in the present invention

30 [0066] On the basis of the study results of the bioavailability of the organic acid metal compound and the solvate thereof and the study results of the residue of the organic acid metal compound and the solvate thereof in the body of animals, the present invention provides the use of the organic acid metal compound and/or the solvate thereof as an animal feed additive or in the preparation of an animal feed additive.

35 [0067] The “animal” involved in the present invention refers to farmed animals that cannot convert inorganic matters into organic matters, but can only utilize organic matters as foods or feeds to perform vital activities such as ingestion, digestion, absorption, respiration, circulation, excretion, sensation, movement, and reproduction.

The “farmed animals” include poultry, livestock, aquaculture animals, and other animals that are raised in captivity and are legally captured including pets, such as cats and dogs. The term “livestock” refers to, for example, any one of pigs, cattle, horses, goats, sheep, deer, and many useful rodents. The term “poultry” includes, for example, chickens, ducks, geese, quails and pigeons. The term “aquaculture animals” includes, for example, fishes, shrimps, tortoises, and soft-shelled turtles.

[0068] The organic acid metal compounds and/or the solvates thereof provided in the present invention are used as or in the preparation of growth promoters for animals at various growth stages, wherein the animals may be selected from livestock, poultry, aquaculture animals or other animals including pets at various growth stages.

[0069] Further, the livestock include, but are not limited to, pigs, cattle, sheep, deer, horses, rabbits, mink or donkeys; the poultry include, but are not limited to, chickens, turkeys, ducks, geese, quails or pigeons; the aquaculture animals include, but are not limited to, fishes, shrimps, tortoises, crabs, soft-shelled turtles, bullfrogs, eels or loaches; and the pets, include but are not limited to, dogs or cats of various subspecies.

[0070] In one embodiment, the organic acid metal compound and/or the solvate thereof provided in the present invention is used as or in the preparation of a feed additive for improving production performance of hogs, wherein the feed additive has significant effects on improving both the average daily gain and feed conversion rate of the hogs.

[0071] In another embodiment, the organic acid metal compound and/or the solvate thereof provided in the present invention is used as or in the preparation of a feed additive for improving production performance of broilers or laying hens, wherein the feed additive can significantly improve the production performance of the broilers or the laying hens.

[0072] In another embodiment, the organic acid metal compound and/or the solvate thereof provided in the present invention is used as or in the preparation of a feed additive for improving production performance of meat ducks, wherein the feed additive can significantly improve the production performance of the meat ducks.

[0073] In another embodiment, the organic acid metal compound and/or the solvate thereof provided in the present invention is used as or in the preparation of a feed additive for improving production performance of fishes, wherein the feed additive can significantly improve the production performance of the fishes.

Compositions involved in the present invention

[0074] The “composition” involved in the present invention refers to a collection or a set of compounds comprising one or more compounds, and further refers to a collection or a set of compounds comprising one or more compounds as active ingredients or components.

[0075] The composition provided in the present invention comprises the aforementioned organic acid metal compound and/or the solvate thereof, and further, the composition comprises the aforementioned organic acid metal compound and/or the solvate thereof as an active ingredient or component.

[0076] The organic acid metal compound and/or the solvate thereof consists of one or more compounds having molecular formulas of $Al_n(R^1)_n(OH)_n(OH)_n$,

$Al_n(R^1)_n(R^2)_n(OH)_n$ and $Al_n(R^1)_n(R^2)_n(R^3)_n$, wherein R^1 is selected from $Y-C(O)O$ or a plant polyphenol, and each of R^2 and R^3 is independently selected from $-OH$, $Y-C(O)O$ - or a plant polyphenol; and preferably, the organic acid metal compound and/or the solvate thereof consists of one or more compounds having molecular formulas of $Al_n(R^1)_n(OH)_n(OH)_n$, $Al_n(R^1)_n(R^1)_n(OH)_n$ and $Al_n(R^1)_n(R^1)_n(R^1)_n$, wherein R^1 , R^2 and R^3 represent $Y-C(O)O$ - or a plant polyphenol.

[0077] Further, the composition comprising the aforementioned organic acid metal compound and/or the solvate thereof provided in the present invention further comprises one or a combination of an adjuvant acceptable in feeds, an additional animal feed additive, and an animal feed raw material.

[0078] Further, in the organic acid metal compound and/or the solvate thereof provided in the present invention, the solvate of the organic acid metal compound is selected from one, more than one or a combination of a hydrate, an acetone solvate, an ethanol solvate, a methanol solvate, a dimethyl sulfoxide solvate, an ethyl acetate solvate, an acetic acid solvate, and/or an isopropanol solvate of the organic acid metal compound.

[0079] Still further, the aforementioned organic acid metal compound and/or the solvate thereof is selected from individual one or more organic acid metal compounds having the same or different molecular formulas, individual one or more solvates of organic acid metal compounds having the same or different molecular formulas, or a combination of one or more organic acid metal compounds having the same or different molecular formulas and one or more solvates of organic acid metal compounds having the same or different molecular formulas;

[0080] Still further, the aforementioned organic acid metal compound includes an organic acid metal compound monomer or an organic acid metal compound polymer.

[0081] In the present invention, the term “comprise” herein is an open-ended expression that encompasses both the content explicitly indicated in the present invention and the content from other aspects.

[0082] Still further, the adjuvant acceptable in feeds is selected from one or more a carrier, a diluent, an excipient, and a vehicle.

[0083] The “carrier” involved in the present invention refers to a substance that is acceptable in feeds, has the ability to carry active ingredients and improve their dispersibility, and exhibits good chemical stability and adsorbability, including an organic carrier and an inorganic carrier. The organic carrier is selected from a material containing much crude fibers, including, but not limited to, corn flour, corn cob powder, wheat bran, rice hull powder, defatted rice bran, rice mill by-product, corn stalk powder, peanut shell powder, etc. The inorganic carrier is selected from minerals, further selected from calcium salts and oxides of silicon, and is used in the preparation of a trace element premix, including, but not limited to, calcium carbonate, silicates, vermiculite, zeolite, sepiolite, etc.

[0084] The “diluent” involved in the present invention refers to a substance that enables additive raw materials to be uniformly distributed in a material, and dilutes the high-concentration additive raw materials into a low-concentration premixed agent or premix, which can separate the trace ingredients from each other and reduce the interaction between active ingredients so as to increase the stability of the active

ingredients without affecting the physicochemical properties of the material involved, including an organic diluent and an inorganic diluent. The organic diluent includes, but is not limited to, corn flour, degermed corn flour, dextrose (glucose), sucrose, semolina with bran, stir-fried soybean powder, wheat middling, corn gluten meal, etc.; and the
5 inorganic diluent includes, but is not limited to, limestone, calcium dihydrogen phosphate, shell powder, kaolin (white clay), table salt and sodium sulfate.

[0085] The “excipient” involved in the present invention refers to a wetting agent that induces the inherent viscosity of a substance, an adhesive that binds substances together, a disintegrating agent that breaks the entire sheet of a substance into many fine
10 particles, a retention aid that reduces the friction between particles, or an anti-sticking agent that prevents materials from adhesion, including, but not limited to, magnesium stearate, talc powder, vegetable oil, magnesium lauryl sulphate, starch, starch slurry, water, inorganic salts, dextrin, powdered sugar, etc.

[0086] The “vehicle” involved in the present invention refers to a solvent required
15 for dissolving or dispersing a solid, including, but not limited to, water, ethanol, glycerol, etc.

[0087] The “feed additive” involved in the present invention refers to a small or trace amount of substances added during feed processing, production, and use, including a nutritional feed additive and a general feed additive, also known as a non-nutritional
20 feed additive.

[0088] The “animal feed additive” involved in the present invention refers to one or more than one of a nutritive feed additive, a general feed additive, or a medicinal feed additive.

[0089] The “nutritive feed additive” involved in the present invention refers to a
25 small amount or trace amount of substances that are added to formula feeds for balancing feed nutrients, improving feed utilization, and directly exerting nutritional effects on animals, including an amino acid, an amino acid salt and an analog thereof, a vitamin and a vitamin-like substance, a mineral element and a complex (chelate) thereof, a microbial enzyme preparation or a nonprotein nitrogen.

[0090] The “general feed additive” involved in the present invention, also known as “non-nutritive additive”, refers to some non-nutritive substances that are added to feeds for improving feed utilization and ensuring feed mass and quality, and are beneficial to animal health or metabolism, including a growth promoter, a deworming agent, a
30 flavoring agent and an attractant, a feed conditioning agent, a feed formulation agent, a feed preservative and a Chinese herbal medicine additive.

[0091] The “feed” involved in the present invention refers to a product that is industrially processed and made for consumption by animals. Unless otherwise stated, the “feed” or “animal feed” includes animal feed raw materials and one or more animal feed additives. In some embodiments, the animal feed raw materials include substances
40 acceptable in feeds, such as grains and processed products thereof, oilseeds and processed products thereof, leguminous crop seeds and processed products thereof, stem tubers, root tubers and processed products thereof, other seed and fruit products and processed products thereof, forage, roughage and processed products thereof, other plants, algae and processed products thereof, dairy products and by-products thereof,
45 terrestrial animal products and by-products thereof, fish, other aquatic organisms and by-

products thereof, minerals, microbial fermentation products and by-products thereof, and other feed raw materials.

Use of compositions

5 [0092] The present invention relates to the use of the above-mentioned composition comprising the aforementioned organic acid metal compound and/or the solvate thereof; and further, the present invention relates to the use of the above-mentioned composition comprising the organic acid metal compound and/or the solvate thereof as an active ingredient or component.

10 [0093] In some embodiments, the composition or the composition acceptable in feeds comprising the organic acid metal compound and/or the solvate thereof is used as an animal feed additive or in the preparation of an animal feed additive.

15 [0094] The composition or the composition acceptable in feeds comprising the organic acid metal compound and/or the solvate thereof is used as an animal feed additive or in the preparation of an animal feed additive, wherein the animal feed additive is selected from a livestock feed additive, a poultry feed additive, an aquaculture animal feed additive or a pet feed additive. In particular, the animal feed additive is an animal growth promoter.

20 [0095] In particular, the composition or the composition acceptable in feeds comprising the organic acid metal compound and/or the solvate thereof is used as a livestock feed additive or in the preparation of a livestock feed additive, wherein the livestock include, but are not limited to, pigs, cattle, goats, horses, rabbits, minks, etc. at various growth stages.

25 [0096] In particular, the composition or the composition acceptable in feeds comprising the organic acid metal compound and/or the solvate thereof is used as a poultry feed additive or in the preparation of a poultry feed additive, wherein the poultry include, but are not limited to, chickens, ducks, geese, pigeons, etc. at various growth stages.

30 [0097] In particular, the composition or the composition acceptable in feeds comprising the organic acid metal compound and/or the solvate thereof is used as an aquaculture animal feed additive or in the preparation of an aquaculture animal feed additive, wherein the aquaculture animals include, but are not limited to, fishes, shrimps, crabs, soft-shelled turtles, eels, etc. at various growth stages.

35 [0098] In particular, the composition or the composition acceptable in feeds comprising the organic acid metal compound and/or the solvate thereof is used as a pet feed additive or in the preparation of a pet feed additive, wherein the pets include, but are not limited to, dogs or cats raised in captivity.

40 [0099] In particular, the composition or the composition acceptable in feeds comprising the organic acid metal compound and/or the solvate thereof is used as an animal feed additive or in the preparation of an animal feed additive, wherein the animal feed additive prepared from the composition or the composition acceptable in feeds comprising the organic acid metal compound and/or the solvate thereof is selected from a premixed agent, a multi-premixed agent, an aqueous agent or granules.

[0100] In some embodiments, the composition or the composition acceptable in feeds comprising the organic acid metal compound and/or the solvate thereof is used as an animal feed or in the preparation of an animal feed.

5 [0101] In particular, the composition or the composition acceptable in feeds comprising the organic acid metal compound and/or the solvate thereof is used as an animal feed or in the preparation of an animal feed, wherein the animal feed is selected from a livestock feed, a poultry feed, an aquaculture animal feed or a pet feed.

10 [0102] In particular, the composition or the composition acceptable in feeds comprising the organic acid metal compound and/or the solvate thereof is used as a livestock feed or in the preparation of a livestock feed, wherein the livestock include, but are not limited to, pigs, cattle, goats, horses, rabbits, minks, etc. at various growth stages.

15 [0103] In particular, the composition or the composition acceptable in feeds comprising the organic acid metal compound and/or the solvate thereof is used as a poultry feed or in the preparation of a poultry feed, wherein the poultry include, but are not limited to, chickens, ducks, geese, pigeons, etc. at various growth stages.

20 [0104] In particular, the composition or the composition acceptable in feeds comprising the organic acid metal compound and/or the solvate thereof is used as an aquaculture animal feed or in the preparation of an aquaculture animal feed, wherein the aquaculture animals include, but are not limited to, fishes, shrimps, crabs, soft-shelled turtles, eels, etc. at various growth stages.

[0105] In particular, the composition or the composition acceptable in feeds comprising the organic acid metal compound and/or the solvate thereof is used as a pet feed or in the preparation of a pet feed, wherein the pets include, but are not limited to, dogs or cats raised in captivity.

25 [0106] In some embodiments, the composition or the composition acceptable in feeds comprising the organic acid metal compound and/or the solvate thereof is used as a feed or in the preparation of a feed, wherein the feed is selected from a single feed, a concentrated feed, a formula feed, a multi-premix or a concentrate supplement.

[0107] In particular, the formula feed is a complete formula feed.

30 **Method for improving production performance of farmed animals**

[0108] The present invention provides a method for improving production performance of an animal, wherein the method comprises administering to the animal an organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or a solvate thereof, or comprises administering to the animal a composition comprising an organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or a solvate thereof as an active component.

40 [0109] In some embodiments, the organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or the solvate thereof, or the composition comprising the organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or the solvate thereof as an active component, is provided for consumption by animals in combination with a feed; and the application of the organic acid metal compound and/or the solvate thereof, or the application of the composition can significantly improve the production performance of the animals.

[0110] In some embodiments, the organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or the solvate thereof is uniformly mixed with an animal feed for consumption by animals.

5 [0111] In some embodiments, the composition comprising the organic acid metal compound and/or the solvate thereof is selected from a premixed agent, a multi-premixed agent, granules or an aqueous agent, and the composition comprising the organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or the solvate thereof as an active component is uniformly mixed with an animal feed for consumption by animals.

10 [0112] In particular, the animals are selected from livestock, poultry, aquaculture animals or pets.

[0113] In particular, the livestock include, but are not limited to, pigs, cattle, goats, horses, rabbits, minks, etc. at various growth stages; the poultry include, but are not limited to, chickens, ducks, geese, pigeons, etc. at various growth stages; the aquaculture
15 animals include, but are not limited to, fishes, shrimps, crabs, soft-shelled turtles, eels, etc. at various growth stages; and the pets include, but are not limited to, dogs or cats raised in captivity.

[0114] In one embodiment, the organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or the solvate thereof, or the composition comprising
20 the organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or the solvate thereof as an active component, is provided for consumption by weaned pigs in combination with a feed, which can significantly improve the weight gain rate of average daily gain and the feed conversion rate of the weaned pigs.

[0115] In one embodiment, the organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or the solvate thereof, or the composition comprising
25 the organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or the solvate thereof as an active component, is provided for consumption by broilers in combination with a feed, which can significantly reduce the feed conversion ratio and improve the feed conversion rate of the broilers.

30 [0116] In one embodiment, the organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or the solvate thereof, or the composition comprising the organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or the solvate thereof as an active component, is provided for consumption by fishes in combination with a feed.

35 [0117] In one embodiment, the organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or the solvate thereof, or the composition comprising the organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ or the solvate thereof as an active component, is provided for consumption by puppies in combination with a feed.

40 [0118] In some other embodiments, the aforementioned composition comprising the organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or the solvate thereof as an active component is provided for consumption by animals, which can significantly improve the production performance of the animals.

[0119] Optionally, the composition is selected from a premixed agent of a feed additive, a multi-premixed agent of a feed additive, granules or an aqueous agent, and/or is provided for consumption by animals in combination with a feed.

[0120] In one embodiment, the composition is a premixed agent of a feed additive.

5 [0121] In one embodiment, the composition is a multi-premixed agent of a feed additive.

[0122] Optionally, the composition is a concentrated feed, a formula feed, a multi-premix or a concentrate supplement, or is provided directly as an animal feed for consumption by animals.

10 [0123] In one embodiment, the composition is a complete formula feed.

Detailed Description of Embodiments

[0124] In order to make the purposes, technical solutions and advantages of the present invention clearer, the compounds, compositions and uses of the present invention are further illustrated in detail below by way of examples. It should be understood that the specific examples described herein are merely used to explain the present invention, but are not intended to limit the present invention.

[0125] **Example 1** Effect of organic acid metal compounds on growth performance of piglets

20 [0126] Two hundred of 45-day-old Duroc×Landrace×Yorkshire heterozygous lean piglets with similar weights were randomly divided into 10 treatment groups, with 2 replicates per group and 10 piglets per replicate (half male and half female). The specific grouping was as shown in Table 1. Pigsty and utensils were disinfected before the experiment. In the experimental period, the animals were held in separate pens in the same pigsty under the same raising and management conditions. During the experiment, the experimental piglets had free access to food and water. Group A was the blank control group, and provided with nursery feeds only; and experimental groups B-H were provided with nursery feeds containing different organic acid metal compounds respectively. No additional antioxidant ingredients and growth promoters were added to each experimental group throughout the raising process. The experimental period was 28 days, and the growth performance of the experimental piglets was recorded. The average daily feed intake (ADFI, g/d*the number of piglets), average daily gain (ADG, g/d*the number of piglets) and feed conversion ratio (FCR) of the experimental piglets were expressed as “mean values”, as shown in Table 1.

35 [0127] Feed conversion ratio (FCR) = average daily feed intake/average daily gain;
Weight gain rate = (experimental group ADG - control group ADG)/control group ADG*100%;

[0128] Feed intake increase rate = (experimental group ADFI - control group ADFI)/control group ADFI*100%;

40 [0129] Feed conversion ratio decrease rate = (control group FCR - experimental group FCR)/control group FCR*100%.

[0130] Table 1 Effect of organic acid metal compounds on growth performance of piglets

Item	Sample/Addition amount (ppm)	Number of experiments	ADFI	Feed intake increase rate (%)	ADG	Weight gain rate (%)	FCR	Feed conversion ratio decrease rate (%)
Group A	0	10*2	706	-	351	-	2.01	-
Group B	Al acetate /1000	10*2	713	0.99	394	12.25	1.81	10.03
Group C	Al butyrate/500	10*2	794	12.46	441	25.64	1.80	10.49
Group D	Al caprate/2000	10*2	760	7.65	419	19.37	1.81	9.82
Group E	14Al/1000	10*2	733	3.82	411	17.09	1.78	11.33
Group F	Al palmate/1000	10*2	757	7.22	419	19.37	1.81	10.18
Group G	Al benzoate/1000	10*2	780	10.48	438	24.79	1.78	11.46
Group H	NAI/500	10*2	762	7.93	430	22.51	1.77	11.90
Group I	KAI/500	10*2	726	2.83	406	15.67	1.79	11.10
Group J	RAI/500	10*2	721	2.12	399	13.68	1.81	10.16

[0131] The above results showed that the organic acid metal compounds involved in the experiment had obvious effects on improving or enhancing the feed conversion rate of the experimental piglets, as represented by a decrease of 9.82%-11.90% in the feed conversion ratio compared to the blank control group. In addition, in terms of weight gain, the average daily gain of the experimental group increased by 12.25%-25.64% compared to that of the blank control group, and in terms of feed intake, Al butyrate, Al caprate, Al palmate, Al benzoate and NAI could increase the feed intake of the experimental piglets to varying degrees.

[0132] **Example 2** Effect of organic acid metal compounds on growth performance of broilers

[0133] In the experiment, single-factor randomized design was used. Six hundred of 1-day-old three-yellow broilers (yellow-feather broilers) with similar weights (average weight of 50 g) were randomly divided into 10 treatment groups, with 3 replicates per group and 20 three-yellow broilers (yellow-feather broilers) per replicate (half male and half female). The grouping was as shown in Table 2. Chicken houses and utensils were disinfected before the experiment. In the experimental period, the animals were caged in the same chicken house under the same raising and management conditions. The basal diet was mainly corn-soybean meal, and no additional antioxidant ingredients and growth promoters were added throughout the raising process. Experimental group A was the control group, and provided with the basal diet only; and experimental groups B-H were provided with the basal diet plus 250 ppm organic acid metal compounds respectively, as shown in Table 2. The experimental period was 20 days in total. The experimental broilers had free access to food and water, and were fed twice a day. With each replicate as one unit, the broilers were weighed at 21 days of age (withholding feeds for 12 h, but allowing

access to water), the feed consumption of the experimental broilers was recorded, and the average daily feed intake (ADFI, g/d*the number of broilers), average daily gain (ADG, g/d*the number of broilers) and feed conversion ratio (FCR) of the experimental broilers in each group were calculated according to the following calculation formulas:

[0134] Feed conversion ratio (FCR) = average daily feed intake/average daily gain;

[0135] Weight gain rate = (experimental group ADG - control group ADG)/control group ADG*100%;

[0136] Feed intake increase rate = (experimental group ADFI - control group ADFI)/control group ADFI*100%;

[0137] Feed conversion ratio decrease rate = (control group FCR - experimental group FCR)/control group FCR*100%.

[0138] The experimental results were as shown in Table 2.

[0139] Table 2 Application effect of organic acid metal compounds in feeds for broilers

Item	Sample/ Addition amount (ppm)	ADFI	Feed intake increase rate (%)	ADG	Weight gain rate (%)	FCR	Feed conversion ratio decrease rate (%)
Group A	0	29.8	-	11.2	-	2.66	-
Group B	Al acetate /1000	33.5	12.42	14.3	27.68	2.34	11.95
Group C	Al butyrate/500	34.9	17.11	15.1	34.82	2.31	13.13
Group D	Al caprate/250	38.7	29.87	16.9	50.89	2.29	13.94
Group E	14Al/100	35.1	17.79	15.3	36.61	2.29	13.78
Group F	Al palmate/250	33.8	13.42	14.7	31.25	2.30	13.58
Group G	Al benzoate/250	35.3	18.46	15.3	36.61	2.31	13.29
Group H	NAI/250	34.5	15.77	15.0	33.93	2.30	13.56
Group I	KAI/250	32.6	9.40	14.1	25.89	2.31	13.10
Group J	RAI/250	34.5	15.77	15.1	34.82	2.28	14.13

[0140] The above results showed that the organic acid metal compounds involved in the experiment had obvious effects on improving or enhancing the feed intake, average daily gain and feed conversion rate of the experimental broilers, and the experimental broilers in the experimental groups had an increase of 9.40%-29.87% in the feed intake, an increase of 25.89%-50.89% in the average daily gain, and a decrease of 11.95%-14.13% in the feed conversion ratio compared to those in the blank control group.

[0141] **Example 3** Study on use of organic acid metal compounds in feeds for meat ducks

[0142] Single-factor experimental design was used. Four hundred and eighty of 1-day-old Cherry valley meat ducks with substantially the same weight and good health

status were selected and randomly divided into 8 treatment groups, with 3 replicates per group and 20 ducks per replicate. The control group was a blank feed group, and provided with a basal diet (corn-soybean meal type); and other treatment groups were all sample addition groups, and provided with the basal diet plus different organic acid metal compounds respectively. The experimental period was 42 days in total. See Table 3 for specific animal grouping. During the experiment, the experimental ducks had free access to food and water, and were immunized according to conventional immunization procedures, and the feed intake, feed consumption, preclusion due to death, etc. in each group were observed and recorded every day. The ducks were weighed on an empty stomach at the beginning and end of the experiment. After the end of the experiment, with each replicate as one unit, the average daily gain, average daily feed intake, and the ratio of feed consumption weight over animal weight gain were statistically analyzed for each treatment group, and the results were as shown in Table 3.

[0143] Table 3 Application effect of organic acid metal compounds in feeds for meat ducks

Item	Sample/ Addition amount (ppm)	Average daily feed intake (g/d)	Feed intake increase rate (%)	Average daily gain (g/d)	Weight gain rate (%)	Feed conversion ratio	Feed conversion ratio decrease rate (%)
Group A	0	179	-	76.27	-	2.35	-
Group B	Al acetate /500	192	7.26	91.33	19.75	2.10	10.42
Group C	Al butyrate/250	205	14.53	98.87	29.63	2.07	11.65
Group D	Al caprate/250	189	5.59	90.81	19.06	2.08	11.32
Group E	14Al/100	212	18.44	101.35	32.88	2.09	10.87
Group F	Al palmate/250	198	10.61	95.86	25.69	2.07	11.99
Group G	Al benzoate/250	221	23.46	105.94	38.90	2.09	11.11
Group H	NAI/250	208	16.20	100.36	31.59	2.07	11.69

[0144] The above results showed that the organic acid metal compounds involved in the experiment had obvious effects on improving or enhancing the feed intake, average daily gain and feed conversion rate of the experimental ducks, and the experimental ducks in the experimental groups had an increase of 7.26%-23.46% in the feed intake, an increase of 19.06%-38.90% in the average daily gain, and a decrease of 10.42%-11.99% in the feed conversion ratio compared to those in the blank control group.

[0145] **Example 4** Study on effect of Al benzoate compound on production performance of laying hens

[0146] For laying hen flocks (Hy-Line gray, 277-day-old, 38395 hens) having stable production performance, data of normal production were collected for two consecutive weeks, and then Al benzoate compounds (abbreviated as "Al benzoate") (500 g/ton) were added to a complete formula feed for observing 33 days. After that, the experiment was performed for another 33 days using the complete formula feed without adding Al benzoate. Data such as egg production, preclusion due to death, feed consumption, temperature and humidity were collected daily, and summarized once every two weeks

or so as an experimental phase. The whole experiment consisted of five phases, namely pre-control phase (14 days), Al benzoate I phase (14 days), Al benzoate II phase (19 days), post-control I phase (14 days) and post-control II phase (19 days). In addition, some eggs were randomly taken every week and tested for the thickness and strength of eggshells.

[0147] Detailed production performance data were as follows: (1) increase in egg production rate: the egg production rate of the laying hen flocks increased from 91.71% in the pre-control phase to 93.57% (Al benzoate I phase) and 93% (Al benzoate II phase); and after withholding, the egg production rate decreased to 91.72% (post-control I phase) and 91.96% (post-control II phase), which were comparable to that in the pre-control phase; (2) improvement in feed-to-egg ratio: the feed-to-egg ratio in the pre-control phase was 2.063:1; the feed-to-egg ratio in the experimental phases was significantly improved and decreased to 2.0:1 (Al benzoate I phase) and 1.970:1 (Al benzoate II phase); and after withholding Al benzoate, the feed-to-egg ratio was 1.976 (post-control I phase) and 1.996 (post-control II phase), respectively; (3) decrease in daily feed intake: after using Al benzoate, the average daily feed intake decreased from 116.79 g to 115.27 g (Al benzoate I phase) and 112.69 g (Al benzoate II phase); and (4) no significant change in the thickness of eggshell.

[0148] The comprehensive statistics from experimental data fully showed that the use of Al benzoate in laying hen flocks provided improved intestinal health, increased egg production rate, decreased feed-to-egg ratio, decreased daily feed intake, and downward trend in average egg weight. Moreover, after withholding Al benzoate, the laying hen flocks still showed an improved trend in the production performance, suggesting a sustained after-effect.

[0149] **Example 5** Analysis and study on residues of different organic acid metal compounds in different animals

[0150] I. Experimental animals: White-feather broilers (1-day-old), yellow-feather broilers (1-day-old), meat ducks (1-day-old), pigs (15 kg), and laying hens (eggs)

[0151] II. Experimental method:

[0152] 1. High levels of organic acid metal compounds were added to a feed, and muscle or tissue samples were taken at different days of age in a 3-6 month long-term feeding experiment and detected for the content of Al, as shown in Tables 4-10.

[0153] 2. The experimental design included a blank control group without the addition of the organic acid metal compounds.

[0154] 3. The content of Al in the feed after the addition of different organic acid metal compounds was tested.

[0155] III. Experimental results

[0156] (I) Experimental results of white-feather broilers

[0157] Table 4 Detection results of white-feather broilers (40-day-old)

Added sample and dosage (g/kg feed)	Leg muscle (ppm)	Pectoral muscle (ppm)	Liver (ppm)
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Blank control group	ND	ND	ND
TAI-4.0 g/kg	ND	ND	ND
14AI-2.0 g/kg	ND	ND	ND
AI benzoate-2.0 g/kg	ND	ND	ND
AI butyrate-2.0 g/kg	ND	ND	ND
NAI-1.0 g/kg	ND	ND	ND
Notes: detection limit is 0.5 ppm, and “ND” means no AI detected.			

[0158] (II) Experimental results of yellow-feather broilers

[0159] Table 5 Detection results of yellow-feather broilers at 40 days of age

Added sample and dosage (g/kg feed)	Leg muscle (ppm)	Pectoral muscle (ppm)	Liver (ppm)	Fat (ppm)
Commercially available broiler	0.98			
Blank control group	1.7	1.6	1.4	1.5
TAI-0.6 g/kg	0.97	0.92	ND	0.83
TAI-1.2 g/kg	ND	ND	1.0	0.95
TAI-2.4 g/kg	0.84	ND	ND	1.1
14AI-0.3 g/kg	ND	ND	ND	0.97
14AI-1.0 g/kg	ND	ND	ND	1.2
AI benzoate-1.0 g/kg	ND	ND	ND	1.4
AI benzoate-2.0 g/kg	1.1	1.2	ND	0.96
AI butyrate-2.0 g/kg	0.84	1.0	ND	0.8
NAI-1.0 g/kg	ND	ND	ND	ND
Notes: detection limit is 0.5 ppm, and “ND” means no AI detected.				

5 **[0160]** Table 6 Detection results of yellow-feather broilers at 80 days of age

Added sample and dosage (g/kg feed)	Leg muscle (ppm)	Pectoral muscle (ppm)	Liver (ppm)	Fat (ppm)	Feed (ppm)
Blank control group	1.9	1.48	0.752	7.2	143
TAI-0.6 g/kg	ND	0.676	ND	0.89	173
TAI-1.2 g/kg	ND	0.950	ND	ND	209
TAI-2.4 g/kg	0.9	1.12	0.511	1.4	211

14Al-0.3 g/kg	ND	1.0	0.88	1.1	168
14Al-1.0 g/kg	0.95	1.05	ND	1.2	179
Al benzoate-1.0 g/kg	ND	0.728	ND	1.6	169
Al benzoate-2.0 g/kg	ND	ND	ND	1.1	243
Al butyrate-2.0 g/kg	1.0	0.539	ND	2.7	240
NA-1.0 g/kg	3.9	0.518	ND	1.7	239
Notes: detection limit is 0.5 ppm, and “ND” means no Al detected.					

[0161] Table 7 Detection results of yellow-feather broilers at 120 days of age

Added sample and dosage (g/kg feed)	Leg muscle (ppm)	Pectoral muscle (ppm)	Liver (ppm)	Fat (ppm)	Egg (ppm)
Blank control group	2.2	2.3	2.24	2.5	6.6
TAI-0.6 g/kg	ND	ND	1.49	ND	ND
TAI-1.2 g/kg	ND	ND	ND	ND	ND
TAI-2.4 g/kg	ND	2.7	ND	ND	ND
14Al-0.3 g/kg	ND	ND	ND	ND	ND
14Al-1.0 g/kg	ND	ND	ND	1.3	ND
Al benzoate-1.0 g/kg	ND	ND	ND	ND	ND
Al benzoate-2.0 g/kg	2.1	ND	1.98	ND	ND
Al butyrate-2.0 g/kg	0.82	1.0	1.57	ND	ND
NAI-1.0 g/kg	1.8	ND	1.32	0.86	ND
Notes: detection limit is 0.5 ppm, and “ND” means no Al detected.					

[0162] (III) Experimental results of laying hens

- 5 **[0163]** The content of Al in eggs was the content of Al detected in eggs before use of or 1-4 weeks after use of organic acid metal compounds.

[0164] Table 8 Detection results of content of Al in eggs

Sample	Before use (ppm)	1 week after use (ppm)	2 weeks after use (ppm)	3 weeks after use (ppm)	4 weeks after use (ppm)
Blank control group	6.6	4.0	6.5	5.4	3.3
TAI-0.6 g/kg	ND	ND	ND	ND	ND
TAI-1.2 g/kg	ND	ND	ND	ND	ND
TAI-2.4 g/kg	ND	ND	ND	ND	ND
14Al-0.3 g/kg	ND	ND	ND	ND	ND

14Al-1.0 g/kg	ND	ND	ND	ND	ND
Al benzoate-1.0 g/kg	ND	ND	ND	ND	ND
Al benzoate-2.0 g/kg	ND	ND	ND	ND	ND
Al butyrate-2.0 g/kg	ND	ND	ND	ND	ND
NAI-1.0 g/kg	ND	ND	ND	ND	ND
Notes: detection limit is 0.5 ppm, and “ND” means no Al detected.					

[0165] (IV) Experimental results of ducks

[0166] Table 9 Detection results of duck samples (40-day-old)

Added sample and dosage (g/kg feed)	Leg muscle (ppm)	Pectoral muscle (ppm)	Liver (ppm)
Blank control group	2.14	2.21	1.19
TAI-4.0 g/kg	1.31	1.55	0.74
14Al-2.0 g/kg	1.30	1.14	0.90
Al benzoate-2.0 g/kg	0.79	1.04	0.43
Al butyrate-2.0 g/kg	0.64	1.28	1.08
NAI-1.0 g/kg	0.57	0.95	0.88
Notes: detection limit is 0.5 ppm, and “ND” means no Al detected.			

5 **[0167]** (V) Experimental results of pigs

[0168] Table 10 Summary of detection results of experimental pig samples

Sample	Dosage (g/kg)	First time (40 days) (ppm)			Second time (120 days) (ppm)			Third time (180 days) (ppm)		
		Muscle (leg)	Liver	Feed	Liver	Muscle (leg)	Muscle (back)	Liver	Muscle (leg)	Muscle (back)
Blank control	0	ND	ND	103	ND	ND	ND	ND	ND	ND
TAI	5	ND	ND	362	ND	ND	ND	ND	ND	ND
14Al	2	ND	ND	225	ND	ND	ND	ND	ND	ND
Al benzoate	4	ND	ND	476	ND	ND	ND	ND	ND	ND
Al butyrate	3	ND	ND	528	ND	ND	ND	ND	ND	ND
Notes: detection limit is 0.5 ppm, and “ND” means no Al detected.										

10 **[0169]** In the present invention, it is confirmed through animal farming experiments that the organic acid metal compound and/or the solvate thereof provided in the present invention can effectively make animals gain weight and increase feed conversion rate, and has a good effect on improving production performance of animals; and more notably,

- the organic acid metal compound and/or the solvate thereof provided in the present invention basically has no residues remaining in muscles, liver and other tissues of food animals, and the content of element aluminum is below the instrumental detection limit of detection institutions for element aluminum or below the content of element aluminum
- 5 in commercially available meat products or below the content of element aluminum in the meat of food animals in a blank control group without receiving organic acid metal compounds, which meets the requirements for the residual amount of aluminum in food specified in GB 2760-2014 (standard for uses of food additives) [the residual amount of aluminum ≤ 100 mg/kg (equivalent to 100 ppm), (dry sample, in terms of Al)].
- 10 **[0170]** The above examples merely represent several embodiments of the present invention, giving specifics and details thereof, but should not be understood as limiting the scope of the present patent of invention thereby. It should be noted that a person of ordinary skill in the art could also make several alterations and improvements without departing from the spirit of the present invention and these would all fall within the scope
- 15 of protection of the present invention. Therefore, the scope of protection of the present patent of invention shall be in accordance with the appended claims.

Claims

1. Use of an organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or a solvate thereof as an animal feed additive or in the preparation of an animal feed additive:

wherein n is any natural number; R^1 is selected from Y-C(O)O- or a plant polyphenol, and each of R^2 and R^3 is independently selected from -OH, Y-C(O)O- or a plant polyphenol;

- Y is selected from H, linear or branched C₁-C₁₉ alkyl or linear or branched C₁-C₁₉ alkyl substituted with 1-5 R^4 , C₃-C₇ cycloalkyl or C₃-C₇ cycloalkyl substituted with 1-5 R^4 , C₃-C₇ cycloheteroalkyl or C₃-C₇ cycloheteroalkyl substituted with 1-5 R^4 , C₅-C₁₂ aryl or C₅-C₁₂ aryl substituted with 1-5 R^5 , C₅-C₁₂ heteroaryl or C₅-C₁₂ heteroaryl substituted with 1-5 R^5 , -(CH=CH)_m-(C₅-C₁₂ aryl) or -(CH=CH)_m-(C₅-C₁₂ aryl) in which the C₅-C₁₂ aryl is substituted with 1-5 R^5 , -(CH=CH)_m-(C₅-C₁₂ heteroaryl) or -(CH=CH)_m-(C₅-C₁₂ heteroaryl) in which the C₅-C₁₂ heteroaryl is substituted with 1-5 R^5 ;

m is any natural number;

R^4 is selected from -OH, -NH₂, -CN, -SH or -X₁, wherein X₁ is selected from F, Cl, Br or I;

- and R^5 is selected from -OH, -NH₂, -NO₂, -CN, -SH, -X₂, -C₁-C₅ alkoxy, -C₁-C₅ alkyl, or X₂-substituted -C₁-C₅ alkyl, wherein X₂ is selected from F, Cl, Br or I.

2. The use according to claim 1, wherein the organic acid metal compound and/or the solvate thereof has a compound molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$, wherein R^1 is selected from a plant polyphenol, each of R^2 and R^3 is independently selected from -OH or a plant polyphenol, and preferably R^1 is tannic acid, and each of R^2 and R^3 is independently selected from OH or tannic acid.

3. The use according to claim 1, wherein the organic acid metal compound and/or the solvate thereof has a compound molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$, wherein R^1 is selected from Y-C(O)O-, each of R^2 and R^3 is independently selected from -OH or Y-C(O)O-, Y is selected from linear or branched C₁-C₁₅ alkyl or linear or branched C₁-C₁₅ alkyl substituted with 1-5 R^4 , and R^4 is selected from -OH, -NH₂, -CN, -SH or -X₁, wherein X₁ is selected from F, Cl, Br or I;

- or, wherein R^1 is selected from Y-C(O)O-, each of R^2 and R^3 is independently selected from -OH or Y-C(O)O-, Y is selected from C₄-C₅ cycloheteroalkyl or C₄-C₅ cycloheteroalkyl substituted with 1-5 R^4 , and R^4 is selected from -OH, -NH₂, -CN, -SH or -X₁, wherein X₁ is selected from F, Cl, Br or I;

- or, wherein R^1 is selected from Y-C(O)O-, each of R^2 and R^3 is independently selected from -OH or Y-C(O)O-, Y is selected from phenyl or phenyl substituted with 1-5 R^5 , and R^5 is selected from -OH, -NH₂, -NO₂, -CN, -SH, -X₂, -C₁-C₅ alkoxy, -C₁-C₅

alkyl, or X₂-substituted -C₁-C₅ alkyl, wherein X₂ is selected from F, Cl, Br or I;

or, wherein R¹ is selected from Y-C(O)O-, each of R² and R³ is independently selected from -OH or Y-C(O)O-, Y is selected from C₄-C₅ heteroaryl or C₄-C₅ heteroaryl substituted with 1-5 R⁵, wherein the heteroaryl contains O, S or N, and R⁵ is selected from -OH, -NH₂, -NO₂, -CN, -SH, -X₂, -C₁-C₅ alkoxy, -C₁-C₅ alkyl, or X₂-substituted -C₁-C₅ alkyl, wherein X₂ is selected from F, Cl, Br or I; preferably, Y is 3-pyridyl;

or, wherein R¹ is selected from Y-C(O)O-, each of R² and R³ is independently selected from -OH or Y-C(O)O-, Y is selected from -(CH=CH)_m-phenyl or -(CH=CH)_m-phenyl in which the phenyl is substituted with 1-5 R⁵, m is any natural number, and R⁵ is selected from -OH, -NH₂, -NO₂, -CN, -SH, -X₂, -C₁-C₅ alkoxy, -C₁-C₅ alkyl, or X₂-substituted -C₁-C₅ alkyl, wherein X₂ is selected from F, Cl, Br or I; preferably, Y is selected from -(CH=CH)-phenyl.

4. The use according to claim 1, wherein as an animal growth promoter, the organic acid metal compound and/or the solvate thereof is used as an animal feed additive or in the preparation of an animal feed additive.

5. The use according to claim 1, wherein in the organic acid metal compound and/or the solvate thereof, the solvate of the organic acid metal compound is selected from one, more than one or a combination of a hydrate, an acetone solvate, an ethanol solvate, a methanol solvate, a dimethyl sulfoxide solvate, an ethyl acetate solvate, an acetic acid solvate, and/or an isopropanol solvate of the organic acid metal compound; preferably, the organic acid metal compound and/or the solvate thereof is selected from individual one or more organic acid metal compounds having the same or different molecular formulas, individual one or more solvates of organic acid metal compounds having the same or different molecular formulas, or a combination of one or more organic acid metal compounds having the same or different molecular formulas and one or more solvates of organic acid metal compounds having the same or different molecular formulas; and more preferably, the organic acid metal compound includes an organic acid metal compound monomer or an organic acid metal compound polymer.

6. A composition, wherein the composition comprises an organic acid metal compound having a molecular formula of Al_n(R¹)_n(R²)_n(R³)_n and/or a solvate thereof:

wherein n is any natural number of 1-10; R¹ is selected from Y-C(O)O- or a plant polyphenol, and each of R² and R³ is independently selected from -OH, Y-C(O)O- and a plant polyphenol; preferably, R¹ is selected from Y-C(O)O- or tannic acid, and each of R² and R³ is independently selected from -OH, Y-C(O)O- or tannic acid;

Y is selected from H, linear or branched C₁-C₁₉ alkyl or linear or branched C₁-C₁₉ alkyl substituted with 1-5 R⁴, C₃-C₇ cycloalkyl or C₃-C₇ cycloalkyl substituted with 1-5 R⁴, C₃-C₇ cycloheteroalkyl or C₃-C₇ cycloheteroalkyl substituted with 1-5 R⁴, C₅-C₁₂ aryl or C₅-C₁₂ aryl substituted with 1-5 R⁵, C₅-C₁₂ heteroaryl or C₅-C₁₂ heteroaryl substituted with 1-5 R⁵, -(CH=CH)_m-(C₅-C₁₂ aryl) or -(CH=CH)_m-(C₅-C₁₂ aryl) in which the C₅-C₁₂ aryl is substituted with 1-5 R⁵, -(CH=CH)_m-(C₅-C₁₂ heteroaryl) or -(CH=CH)_m-(C₅-C₁₂

heteroaryl) in which the C₅-C₁₂ heteroaryl is substituted with 1-5 R⁵;

m is any natural number;

R⁴ is selected from -OH, -NH₂, -CN, -SH or -X₁, wherein the X₁ is selected from F, Cl, Br or I;

- 5 and R⁵ is selected from -OH, -NH₂, -NO₂, -CN, -SH, -X₂, -C₁-C₅ alkoxy, -C₁-C₅ alkyl, or X₂-substituted -C₁-C₅ alkyl, wherein the X₂ is selected from F, Cl, Br or I.

7. The composition according to claim 6, wherein the composition comprises one, more than one or a combination of organic acid metal compounds having a molecular
10 formula of Al_n(R¹)_n(OH)_n(OH)_n, or Al_n(R¹)_n(R²)_n(OH)_n, or Al_n(R¹)_n(R²)_n(R³)_n and/or solvates thereof; wherein n, each of R¹, R², R³, Y, m, R⁴, R⁵, X₁ and X₂ is as defined in claim 6.

8. The composition according to claim 6, wherein the composition comprises one, more than one or a combination of an organic acid metal compounds having molecular
15 formulas of Al_n(R¹)_n(OH)_n(OH)_n, Al_n(R¹)_n(R¹)_n(OH)_n, and Al_n(R¹)_n(R¹)_n(R¹)_n and/or solvates thereof; wherein n, each of R¹, R², R³, Y, m, R⁴, R⁵, X₁ and X₂ is as defined in claim 6.

9. The composition according to any one of claims 6-8, wherein in the organic acid
20 metal compound and/or the solvate thereof, the solvate of the organic acid metal compound is selected from one, more than one or a combination of a hydrate, an acetone solvate, an ethanol solvate, a methanol solvate, a dimethyl sulfoxide solvate, an ethyl acetate solvate, an acetic acid solvate, and/or an isopropanol solvate of the organic acid
25 metal compound; preferably, the organic acid metal compound and/or the solvate thereof is selected from individual one or more organic acid metal compounds having the same or different molecular formulas, individual one or more solvates of organic acid metal compounds having the same or different molecular formulas, or a combination of one or more organic acid metal compounds having the same or different molecular formulas
30 and one or more solvates of organic acid metal compounds having the same or different molecular formulas; and more preferably, the organic acid metal compound includes an organic acid metal compound monomer or an organic acid metal compound polymer.

10. The composition according to any one of claims 6-9, wherein the composition
35 further comprises an animal feed raw material, and an additional animal feed additive and/or an adjuvant acceptable in feeds, wherein the additional animal feed additive is selected from at least one of a nutritional feed additive, a non-nutritional feed additive, or a medicinal feed additive.

11. Use of the composition according to any one of claims 6-10 as an animal feed
40 additive or in the preparation of an animal feed additive, wherein preferably, the animal feed additive is an animal growth promoter.

12. A method for improving production performance of an animal, wherein the method comprises administering to the animal an organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or a solvate thereof or a composition comprising an organic acid metal compound having a molecular formula of $Al_n(R^1)_n(R^2)_n(R^3)_n$ and/or a solvate thereof:

wherein n is any natural number of 1-10; R^1 is selected from Y-C(O)O- or a plant polyphenol, and each of R^2 and R^3 is independently selected from -OH, Y-C(O)O- and a plant polyphenol; preferably, R^1 is selected from Y-C(O)O- or tannic acid, and each of R^2 and R^3 is independently selected from -OH, Y-C(O)O- or tannic acid;

Y is selected from H, linear or branched C_1 - C_{19} alkyl or linear or branched C_1 - C_{19} alkyl substituted with 1-5 R^4 , C_3 - C_7 cycloalkyl or C_3 - C_7 cycloalkyl substituted with 1-5 R^4 , C_3 - C_7 cycloheteroalkyl or C_3 - C_7 cycloheteroalkyl substituted with 1-5 R^4 , C_5 - C_{12} aryl or C_5 - C_{12} aryl substituted with 1-5 R^5 , C_5 - C_{12} heteroaryl or C_5 - C_{12} heteroaryl substituted with 1-5 R^5 , $-(CH=CH)_m-(C_5-C_{12}$ aryl) or $-(CH=CH)_m-(C_5-C_{12}$ aryl) in which the C_5 - C_{12} aryl is substituted with 1-5 R^5 , $-(CH=CH)_m-(C_5-C_{12}$ heteroaryl) or $-(CH=CH)_m-(C_5-C_{12}$ heteroaryl) in which the C_5 - C_{12} heteroaryl is substituted with 1-5 R^5 ;

m is any natural number;

R^4 is selected from -OH, -NH₂, -CN, -SH or -X₁, wherein the X₁ is selected from F, Cl, Br or I;

and R^5 is selected from -OH, -NH₂, -NO₂, -CN, -SH, -X₂, -C₁-C₅ alkoxy, -C₁-C₅ alkyl, or X₂-substituted -C₁-C₅ alkyl, wherein the X₂ is selected from F, Cl, Br or I.