

DICTIONARY  
OF  
PLANT FOODS  
AND  
PESTICIDES

(SECTION C. & D. OF *FARM CHEMICALS HANDBOOK* 1964)

# DICTIONARY of PLANT FOODS

# 1964

## SECTION-C

The Dictionary of Plant Foods contains over 400 definitions of fertilizer substances together with 73 tables listing composition analyses. Association of American Fertilizer Control Officials definitions are also listed wherever available. This is the seventh revision by Arnon L. Mehring who is consulting editor to FARM CHEMICALS\* magazine, author or co-author of more than 100 government bulletins and technical journal articles on fertilizer technology, and until his retirement, was senior chemist in charge of fertilizer statistics in the U. S. Department of Agriculture.



DICTIONARY of  
PLANT FOODS



Custom applicator pumps liquid fertilizer from nurse tank to tractor-mounted applicator for use in cotton field.

# DICTIONARY OF PLANT FOODS

REVISED BY ARNON L. MEHRING\*

THE FERTILIZER INDUSTRY of today is largely a chemical industry; in fact, it is the largest of the industries producing heavy chemicals. A century ago fertilizer mixtures consisted largely of by-products, such as tankage, blood, bones, cottonseed meal, and other trade wastes with superphosphate and/or potash salts. Present day fertilizer mixtures are made largely from chemicals. Formerly these materials were gathered from many parts of the world, but at present, all necessary fertilizer materials are produced in the United States. Some materials, because of economic conditions, are, nevertheless, still imported from Canada, Chile, and other countries.

The wise selection, handling, formulating and use of these various materials, as well as liming materials and other farm chemicals, require at least some knowledge of their chemical composition, properties and characteristics.

All chemical substances may be divided into two general classes—organic and inorganic. The term, organic, was originally applied to substances produced by living bodies as distinguished from inorganic substances belonging to the mineral kingdom. Organic materials are now classed as those containing carbon (other than carbonate) as an essential ingredient, and all other materials are classed as inorganic.

Most organic compounds are chemically more complex than the inorganic, and will be only briefly mentioned here.

Inorganic chemicals may be divided into three general classes:

1. Acids.
2. Bases (Alkalies).
3. Salts.

Acids and bases, especially the more common ones, are usually quite active. They have in most cases a corrosive action on the skin, and attack other chemicals with which they come in contact, forming new chemical compounds. Acids are formed by the combination with hydrogen of non-metallic elements (sulfur, nitrogen, chlorine, etc.) or ions composed of these elements and oxygen.

Bases are formed by the combination of metallic elements (calcium, sodium, potassium, iron, etc.) with an ion composed of one atom each of hydrogen and oxygen. Ammonium, also, is a base, but instead of a single metallic element we have here an ion composed of the elements nitrogen and hydrogen ( $\text{NH}_4^+$ ) acting in the role of a metal. The term alkali is applied to the bases containing sodium, potassium, calcium, or ammonium, which are more violent in their action on the skin and on other chemicals than are the weaker bases containing iron, aluminum, lead, etc.

When an acid and a base react together two new chemicals are formed. The hydrogen in the acid combines with hydrogen and oxygen of the base to form water. The metallic element or ion, for example  $\text{NH}_4^+$ , in the base unites with the non-metallic element or ion ( $\text{NO}_3^-$ ) of the acid to form a salt. When an acid acts on a metal the result is somewhat similar to the reaction between an acid and a base. A salt is formed, but instead of water being formed, hydrogen gas is usually produced.

Certain acids and bases are more active than others of their class; that is, a certain base has a greater affinity for one acid than for another; for example, calcium has a greater affinity for sulfuric acid than for phosphoric acid, so when a calcium phosphate, for example phosphate rock, is treated with sulfuric acid, a part or all of the calcium leaves the phosphate and combines with the sulfate ion. This is the reaction taking place when superphosphate, double or triple superphosphate or phosphoric acid ( $\text{H}_3\text{PO}_4$ ) are made. Another instance of stronger affinity is furnished by calcium (lime is calcium oxide) and ammonia. Calcium is the stronger, or more active base, and will replace the ammonia from ammonium sulfate, forming calcium sulfate and liberating ammonia.

Phosphoric acid ( $\text{H}_3\text{PO}_4$ ) is now widely used both as a fertilizer and a fertilizer material. In the past phosphoric oxide ( $\text{P}_2\text{O}_5$ ) was called phosphoric acid. To avoid confusion it has been necessary to use these terms with care.

In reporting analyses of fertilizers and materials it is common practice to give the percentage of the various elements in terms of their oxide; that is, the percentage of the acid or base, minus the water. In fertilizer nomenclature, phosphoric oxide is a combination of two atoms of phosphorus and five atoms of oxygen ( $\text{P}_2\text{O}_5$ ), whereas

\*The first edition of this dictionary was published by T. C. Pinkerton in 1917 in the American Fertilizer Handbook. It has been revised frequently, first by Mr. Pinkerton, and then by H. C. Moore. More than half the material in this edition has been introduced since 1957 by Mr. Mehring.

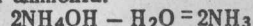


phosphoric acid is actually  $H_3PO_4$ . Deducting water ( $H_2O$ ) from this formula gives  $P_2O_5$ , as  $2H_3PO_4 - 3H_2O = P_2O_5$ .

Caustic potash (potassium hydroxide) is  $KOH$ , but in fertilizers potash refers to  $K_2O$ , or actually potassium oxide, which may be indicated as follows:



Likewise for ammonia:



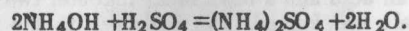
Aqua Ammonia Water Ammonia

Chemical formulas may appear somewhat complicated at first, but are really quite simple. Each chemical element is represented by a letter, or sometimes two letters, as:

Al—Aluminum	Fe—Iron	N—Nitrogen
B—Boron	H—Hydrogen	O—Oxygen
C—Carbon	K—Potassium	P—Phosphorus
Ca—Calcium	Mg—Magnesium	S—Sulfur
Cl—Chlorine	Mn—Manganese	Si—Silicon
Cu—Copper	Mo—Molybdenum	Zn—Zinc

Calcium sulfate, formerly referred to as sulfate of lime, is indicated by the chemical symbol  $CaSO_4$ . The number before a symbol applies to all the elements, but the subscript numbers apply to the elements which they follow, thus:  $2K_2SO_4$  means 4 Potassium (K); 2 Sulfur (S); 8 Oxygen (O).  $H_2O$  is the symbol for water.

In writing the equation for a chemical reaction, the number of elements on each side must balance, thus:



In this equation there are 2 N, 12 H, 1 S and 6 O on each side.

In 1960 the American Society of Agronomy voted to make all its official recommendations and decisions affecting fertilizers in terms of the elements, instead of their oxides. This is already common practice with regard to nitrogen, but the industry will probably continue to recommend and guarantee phosphorus and potassium in terms of their respective oxides, unless compelled to do otherwise by state laws. When recommendations are expressed as percentages or pounds of P or K, they may be converted to percentages or pounds of  $P_2O_5$  or  $K_2O$  by multiplying by 2.2912 or by 1.2046, respectively. (See also Conversion Factors on pages A28 and A29.)

In order to protect the industry and farmers each state has a fertilizer control laboratory where chemical analyses are made of samples collected from dealers and consumers. The results are published periodically in bulletins. Information collected from these publications is given under many of the headings that follow. Much additional information on the composition and properties of fertilizers may be found in Chapter 4 of *Handbook of Food and Agriculture*, edited by F. C. Blanck (Reinhold Pub. Co., 1955).

For the technology of fertilizer manufacture one of the best books is *Fertilizer Technology and Resources in the U. S.*, edited by K. D. Jacob (Academic Press, 1953).

The best source of historical statistics is USDA Statistical Bul. 191 (1957).

The standard for methods of analysis of fertilizers is the *Official Methods of Analysis of the*

*Association of Official Agricultural Chemists*, 1960, P. O. Box 540, Washington 4, D. C.

A few selected references are given as footnotes to the definitions that follow.

#### Acid-forming Fertilizer.

A single material, that tends to increase the acidity of a soil to which it is applied, or a mixture of materials, the net effect of which on the soil is acid-forming.

The AAFCO official definition follows:

"An Acid-Forming Fertilizer is one that is capable of increasing the residual acidity of soil."

#### Acidity and Basicity of Fertilizers.

Acidity or basicity of fertilizers may be either chemical or physiological. Both types are important, but the physiological type is what is meant in guarantees in the fertilizer market. For example, ammonia is strongly basic chemically. This basicity is used in manufacturing ammoniated superphosphate, ammonium sulfate and ammonium phosphate. On the other hand ammonia is physiologically strongly acidic. Either free or in the form of salts ammonia is oxidized in the soil by microorganisms to form nitric acid. The acid part of the salt is released as free acid ions also. Experiments indicate that about one-half of the nitric acid equivalent of the nitrogen present as ammonia or natural organic N is effective on the soil reaction. Nitrates are neutral salts chemically, but in the soil the nitrate part of the salt is absorbed by plants more rapidly than the basic part. This makes the soil more basic or less acid.

Some fertilizer materials leave acid residue in the soil, thus tending to make the soil more acid; some materials leave basic residues tending to make the soil more basic or alkaline; while other materials have neither effect.

The common potash salts, except the nitrate, have no residual effect on soil reaction. Superphosphates have no permanent effect on soil reaction.

The acid residue of any material, measured in terms of calcium carbonate (pure limestone) required to neutralize it, is called equivalent acidity. The basic residue, likewise, of any material is called equivalent basicity.

The equivalent acidity or basicity of commonly used materials follows:

	Pounds of $CaCO_3$ per 100 lbs. of material
Ammonia, anhydrous.....	148A
Ammonia, aqua (21% N).....	38A
Ammonium nitrate.....	59A
Ammonium nitrate, ammonia solutions:	
Type 2A.....	73A
Type 3.....	74A
Type 4.....	67A
Type 6.....	88A
Ammonium nitrate-limestone mixtures (20.5% N).....	0
Ammonium phosphate (11-48).....	65A
Ammonium phosphate sulfate (16-20).....	85A
Ammonium sulfate.....	110A
Basic slag.....	70B

	Pounds of CaCO <sub>3</sub> per 100 lbs. of material
Blood, dried.....	22A
Bone meal.....	20-25B
Borax.....	55B
Calcium cyanamide.....	63B
Calcium nitrate.....	20B
Castor pomace.....	6A
Cocoa shell meal.....	2B
Cottonseed meal.....	10A
Diammonium phosphate (18-46).....	64A
Diammonium phosphate (21-53).....	74A
Dolomite.....	98B
Fish Scrap.....	5A
Furfural waste.....	2A
Guano.....	0-15A
Gypsum (Landplaster).....	0
Limestone.....	90B
Magnesia.....	220B
Manures, dried.....	10-20B
Monopotassium phosphate.....	0
Oyster shell.....	90B
Peanut hull meal.....	6B
Peat.....	3B
Phosphate rock.....	10B
Potassium chloride.....	0
Potassium nitrate.....	26B
Potassium sulfate.....	0
Sewage sludge, activated.....	10A
Sewage sludge, dried.....	5A
Sodium nitrate.....	29B
Sulphate of potash magnesia.....	0
Superphosphate (all grades).....	0
Tankage, animal.....	0-20B
Tankage, garbage.....	5-10B
Tankage, process.....	16A
Tobacco stems.....	12-25B
Tung meal.....	3B
Urea.....	84A
Urea-ammonia solutions.....	82A
Urea-form.....	68A

The above values are based on materials of average composition. For other analyses 36 pounds of CaCO equivalent acidity per unit of N may be used for most nitrogenous compounds, except ammonium salts, nitrates and cyanamid. Ammonium nitrate is 36 pounds acidic and sodium nitrate is 36 pounds basic per unit of N.

Most of these values are based on the work of Pierre.<sup>1</sup>

With the foregoing data it is easy to compute the net equivalent acidity of any mixed fertilizer from its formula, or a fertilizer mixture can be prepared that will be acid forming, neutral, or basic as desired.

(1) W. H. Pierre, "The Equivalent Acidity and Basicity of Fertilizers as Determined by a Newly Proposed Method." (Journal of A.O.A.C., Feb., 1934).

(2) W. H. Pierre, "Determination of Equivalent Acidity and Basicity of Fertilizers." (Ind. and Eng. Chem., 5: 229, 1933 (Analytical Ed.))

Pierre<sup>2</sup> has devised a chemical method for determining in the laboratory the acidity or basicity of a fertilizer material or mixed fertilizer. This method is in common use by fertilizer chemists and state control officials.

#### Acidulated Bone.

The official AAFCO definition follows:

"Acidulated bone is ground bone or bone meal that has been treated with sulfuric acid."

Acidulated Fish Scrap—see Fish Scrap.

Activated Sewage Sludge—see Sewage Sludge.

#### Activity of Water-insoluble Nitrogen in Mixed Fertilizers.

The active insoluble nitrogen determinations given in this dictionary are by the alkaline permanganate method.

The AAFCO has the following tentative regulation:

"The alkaline and neutral permanganate methods distinguish between the better and the poorer sources of water-insoluble nitrogen, and do not show the percentage availability of the material. The available nitrogen of any product can be measured only after carefully conducted vegetation experiments."

"(a) The methods shall be used on mixed fertilizers containing water-insoluble nitrogen amounting to 0.3 per cent or more of the weight of the material. If a total nitrogen exceeds the minimum guaranty and is accompanied by a low activity of the insoluble nitrogen, the over-run shall be taken into consideration in determining the classification of the water-insoluble nitrogen."

"(b) The water-insoluble nitrogen in mixed fertilizers showing an activity below 50 per cent by the alkaline method and also 80 per cent by the neutral method shall be classed as inferior. This necessitates the use of both methods, also the provision as to over-run in (a) before classifying as inferior."

#### Activity Index (A.I.).

An AOAC method for determining the value of urea-form fertilizer.

Actomag—see Selectively Calcined Dolomite.

Agricultural Lime—see Lime.

Agrinite—see Process Tankage.

#### Agstone.

A term widely used to denote agricultural limestone.

#### Alkali.

A strictly chemical definition of an alkali is a compound of hydrogen and oxygen with one of the elements sodium, potassium, or the radical ammonium (NH<sub>4</sub>), etc., characterized by great solubility in water and capable of neutralizing acids. (See introductory paragraph).

Alkylation Acid (Sulfuric)—see Spent Alkylation Acid.



**Alkaline Goods (Alkaline Base).**

A mixture of superphosphate and potash salts. Such a mixture with nothing else added usually reacts to give off free acid. Ground limestone or other basic material is therefore always added to such mixtures to prevent bag-rotting. It is, however, incorrect to call them alkaline and the term is being supplanted by the name "P-K mixtures."

**Alumina (Aluminum Oxide;  $\text{Al}_2\text{O}_3$ ).**

Alumina occurs in small quantities in phosphate rock along with a small percentage of iron and other impurities. The alumina and iron in phosphate rock are detrimental (see Aluminum Phosphate). The maximum amount of alumina and iron in the rock is often guaranteed in the contract, many contracts being made on a basis of not more than 3 to 4 per cent combined iron and alumina (as oxides), commonly referred to as I. and A.

**Aluminum (Al).**

A widely distributed element, commonly found as silicate in various clays and rocks. While aluminum may be essential to the growth of some plants, the amount required, if any, is very small. The supply in all soils is abundant. Some acid soils contain sufficient aluminum in soluble form to kill certain plants. (See Aluminum Sulfate.)

**Aluminum Dross.**

A byproduct of refining aluminum metal. It consists of aluminum oxide, aluminum nitride ( $\text{Al}_2\text{N}_2$ ), salt, and various other impurities. The average N content of 22 samples varied from 0.43 to 11.16%, with an average of 5.33%. The N is slowly available in the soil. It is also relatively high in magnesium, copper, manganese, and zinc contents.

**Aluminum Phosphate ( $\text{AlPO}_4$ ).**

Occurs in quantity in the colloidal or soft phosphates found in Florida. It also occurs in small quantities in all grades of phosphate rock. It is insoluble in water and its phosphoric acid content is but slightly available in the soil unless treated with an acid. Much aluminum phosphate in phosphate rock is objectionable, because of the tendency of the superphosphate made from such rock to become moist and sticky.

**Aluminum Sulfate ( $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$ ).**

It is soluble in water and usually made by treating bauxite with sulfuric acid. It is sometimes applied to soils, especially in the West, to make them less alkaline. In the East it is used to produce an acid condition for such plants as rhododendrons, azaleas, camellias, blueberries, etc.

**Alunite.**

A hydrated sulfate of aluminum and potash mineral. There are large deposits in Utah and other Western states. The potash is insoluble in water, but is rendered soluble by roasting. Roasted material marketed in the West averaged about 6.5%  $\text{K}_2\text{O}$ .

**Amanol** — see Nitrogen Solutions.

**Ammonia ( $\text{NH}_3$ ).**

Ammonia is a gas composed of 82.25 per cent nitrogen and 17.75 per cent hydrogen, chemically combined. Until recent years, most of the ammonia produced in the United States was derived from the destructive distillation of coal in byproduct coke ovens. At the present time, most of the ammonia is produced synthetically. Nitrogen and hydrogen, under proper conditions of temperature and pressure and in the presence of a suitable catalyst, react and combine chemically.

A part of the ammonia is used to produce nitric acid, or urea. From these three materials other fertilizers are manufactured. Thus synthetic ammonia is now the source of most of our fertilizer nitrogen.

In most coke oven plants, ammonia, which is expelled from the coal with the gas, is absorbed in sulfuric acid, forming ammonium sulfate. In some plants the ammonia is recovered by washing the gas with water to form aqua ammonia, or with phosphoric acid to produce ammonium phosphate.

**Ammonia (Liquid Anhydrous).**

Dry ammonia gas is cooled and compressed by suitable mechanical means to liquid form. In this form it is shipped to fertilizer plants in special insulated high pressure tank cars carrying a minimum of 25 tons of anhydrous ammonia. At the fertilizer plant it is used for ammoniating superphosphate either to make base mixtures or to make finished mixed fertilizers, or by mixing with sulfuric acid may be converted into ammonium sulfate. It may be introduced into the superphosphate as anhydrous ammonia directly from the tank cars or from high pressure storage tanks, or first converted to and stored as ammonia liquor by mixing with water. The superphosphate may then be ammoniated with the ammonia liquor, which may contain between 25 and 50 per cent ammonia. However, any aqua solution containing over 30 per cent ammonia must be stored in tanks capable of withstanding considerable pressure.

Effective and inexpensive equipment is available for handling and measuring anhydrous ammonia directly from the tank car to the fertilizer mixers.

Anhydrous ammonia has been applied directly into the soil by suitable distributors since 1946. The ammonia is held by the moisture and colloidal material in the soil and converted to the nitrate form by soil organisms. It has also been applied to the soil through irrigation waters, notably in the Southwest, since 1935.

The fertilizer grade of anhydrous ammonia contains from 98.3 to 99.5 per cent  $\text{NH}_3$ , with an average above 99 per cent.

The specific gravity of the liquid at 60° is 0.62. It weighs 38.5 pounds per cubic foot or 5.15 pounds per gallon. The gauge pressure is 0 at -28°, 14 lbs./sq.in. at 0°, 40 lbs./at 25°, 74 lbs. at 50°, 125 lbs. at 75°, and 197 lbs. at 100° F.

**Ammonia Liquor ( $\text{NH}_4\text{OH}$ ) (Aqua Ammonia) (Ammoniacal B Liquor).**

Ammonia gas and water combined chemically to form ammonium hydroxide ( $\text{NH}_4\text{OH}$ ). This reaction liberates 150 B.T.U. per pound of ammonia. At concentrations above 20 per cent  $\text{NH}_3$  care must be taken to dissipate the heat. At 1 atmosphere pressure water at 32°, 50°, 80°, and 100° F. dissolves 43.7, 37.5, 28 and 23 per cent  $\text{NH}_3$ , respectively, by weight. A 25 per cent solution exerts a pressure of 1 lb./sq. in. at 100° and 9 lbs. at 120°. Aqua ammonia rapidly dissolves many metals. Aqua ammonia made from anhydrous usually contains from 27 to 30 per cent  $\text{NH}_3$  or 22.2 to 24.7 per cent N. It weighs about 7.5 pounds per gallon. The solution is strongly alkaline and unites with strong acids to form ammonium salts; for example, with phosphoric acid ( $\text{H}_3\text{PO}_4$ ) to form ammonium phosphates (which see); with sulfuric acid to form ammonium sulfate (which see); and with nitric acid ( $\text{HNO}_3$ ) to form ammonium nitrate (which see).

"B liquor" is an ammonia solution prepared in a coke oven plant. It contains small amounts of pyridine, cyanide, and other organic compounds, all of which total, as a rule, less than one per cent. It is guaranteed to contain 25 per cent  $\text{NH}_3$ .

**Ammoniation.**

The process of introducing ammonia (liquid anhydrous; ammonia liquor or aqua ammonia; solutions of fertilizer compounds such as ammonium nitrate or urea in a mixture of ammonia and water) into superphosphate, forming ammoniated superphosphate, or into a mixture of superphosphate and other fertilizer ingredients to make fertilizer mixtures.

Various reaction products result, depending on the proportion of ammonia used, temperatures resulting, time of standing, and the other materials included in the mixture. The ammonia reacts with the free acid and the monocalcium phosphate ( $\text{CaH}_4\text{PO}_4$ ), present in the superphosphate, forming other compounds. The water enters the reaction and is mostly fixed as combined water, resulting in dry, well-conditioned products. (See Ammoniated Superphosphate.)

**Ammonia Oxidation.**

When ammonia ( $\text{NH}_3$ ) and air are mixed and passed through a platinum alloy gauze, the ammonia burns, combines with the oxygen of the air, and forms nitric oxide. This oxide combines with water forming nitric acid ( $\text{HNO}_3$ ).

This process is used commercially not only to manufacture ammonium nitrate, but also in the chamber process for the manufacture of sulfuric acid. This replaces the nitric oxide formerly obtained by heating nitrate of soda with sulfuric acid in nitre pots placed in the sulfur combustion chamber.

(3) J. M. Stinson, M. M. Striplin, Jr., N. A. Brown and L. F. Seatz, "Ammonium Metaphosphate Fertilizer." *Agr. & Food Chem.* 4: 248-254 (1956)

**Ammoniating Solutions—see Nitrogen Solutions.****Ammoniated Superphosphate.**

When superphosphate of any grade is brought into contact with free ammonia ( $\text{NH}_3$ ), the ammonia immediately reacts with any free acid and acidic phosphates present. Gypsum, when present, also enters the reactions and thus dicalcium phosphate, monoammonium phosphate and ammonium sulfate are formed.

The AAFCO tentative definition follows:

"Ammoniated superphosphate is a product obtained when superphosphate is treated with ammonia or with solutions which contain ammonia and other compounds of nitrogen. The guaranteed percentages of nitrogen and of available phosphoric acid shall be stated as part of the name."

**Ammoniator.**

An apparatus for introducing ammonia or its solutions into superphosphate or mixed fertilizer. The standard type is a rotating drum with tubes discharging the liquid as a spray inside the apparatus, either continuously or a batch at a time.

**Ammonium Chloride ( $\text{NH}_4\text{Cl}$ ).**

The ammonium salt of hydrochloric acid. It is not produced for fertilizer in this country, but from time to time some has been imported from Europe. Nine samples reported in fertilizer control bulletins during the past 10 years contained from 19.6 to 26.1 per cent N, with an average of 23.4 per cent.

**Ammonium Metaphosphate ( $\text{NH}_4\text{PO}_3$ ).**

The material produced by the Tennessee Valley Authority<sup>3</sup> contains 16.7 per cent total N, 11.7 per cent water-soluble N, 73.4 per cent total  $\text{P}_2\text{O}_5$ , and 51.2 per cent water-soluble  $\text{P}_2\text{O}_5$ .

It is made by burning phosphorus and reacting the resulting vapor with ammonia and then treating with steam.

**Ammonium Nitrate ( $\text{NH}_4\text{NO}_3$ ).**

The ammonium salt of nitric acid. It is prepared by first oxidizing ammonia to nitric acid and then neutralizing a solution of the latter with gaseous ammonia. The resulting solution of ammonium nitrate is concentrated to about 95-98 per cent by evaporation. The hot melt is converted into solid granular ammonium nitrate by graining or spraying. The sprayed material forms small shot-like pellets called "prills."

In the Stengel Process vapors of nitric acid and ammonia are passed into a tubular reactor. The heat of reaction and counter current stream of air reduce the moisture content to the desired level by the time the molten material flows from the reactor. It is flaked on a water-cooled stainless steel belt and then ground and screened to the proper particle size.



Ammonium nitrate changes its crystal form every time it passes through a temperature of 90° F. It also absorbs moisture rapidly from the air when the humidity exceeds about 60 per cent. The exact per cent varies with the temperature. In dry atmospheres the material dries out. Both these processes cause the particles to knit together. The tendency to cake can be greatly reduced by coating the dry material with 4-5 per cent of a conditioning agent, such as kieselguhr, kaolin, clay or tricalcium phosphate, and storing in moisture-proof bags.<sup>4</sup>

Pure ammonium nitrate has a total nitrogen content of 35 per cent. The average N content of many samples reported in 1960 bulletins is 33.77 per cent, with a range from 32.5 to 35.8. The water of constitution is computed to be 10.77 per cent.

It melts at 309° and decomposes at 390°. The fire hazard involved in the use of ammonium nitrate is considered to be essentially the same as for sodium nitrate. The treatment to which ammonium nitrate would normally be subjected in a fertilizer plant does not involve any explosive hazard, but it should not be detonated with dynamite or other explosive, nor stored with combustible materials, nor mixed with organics and superphosphate unless the free acid has been neutralized first.

Ammonium nitrate is now being used as a fertilizer not only when treated with various conditioning agents, but also in mixtures with dolomite (see Ammonium Nitrate-Limestone) and in solution with ammonia and water (see Nitrogen Solution).

The AAFCO official definition follows:

"Ammonium Nitrate is chiefly the ammonium salt of nitric acid. It shall contain not less than 33 per cent of nitrogen, one-half of which is in the ammonium form and one-half in the nitrate form."

#### Ammonium Nitrate-Limestone.

A mixture of ammonium nitrate and finely pulverized limestone (or dolomite), approximately 1200 pounds ammonium nitrate and 800 pounds limestone. A better product results when the ammonium nitrate contains slightly more than half its nitrogen in the ammonia form. It is prepared in pellet or prilled form suitable for mixing or direct application.

It is sold under various trade names, such as Amnical, A-N-L, Calmonite, Cal-Nitro, Kalkamonsalpeter, Nitramonical, Nitro-chalk and Nitrolime. They are all guaranteed to contain 20.5 per cent N. The average of hundreds of samples analyzed in 1960 was 20.90, with a range from 20.26 to 21.12 per cent. Twenty samples contained an average of 7.89 per cent MgO and 8.20 per cent CaO. It is non-explosive and non-inflammable.

The AAFCO has the following official regulation:

"This Association recommends the disapproval of the registration of mixtures of ammonium nitrate and limestone or dolomite under the names—'Ammonium calcium nitrate,' 'Calcium ammonium nitrate' and similar names which imply the presence of either calcium nitrate or ammonium carbonate in such mixtures."

(4) W. H. Ross, J. R. Adams, J. Y. Yee, C. W. Whitaker, and K. S. Love, "Preparation of Ammonium Nitrate for Use as a Fertilizer." U. S. Dept. Agr. Tech. Bul. 912 (1946).

(5) J. G. Getsinger, E. C. Houston and F. P. Achom, "Production of Diammonium Phosphate by Continuous Vacuum Crystallization." Agr. & Food Chem. 5:433-436 (1957).

#### Ammonium Phosphate.

Both monoammonium phosphate and diammonium phosphate are used as fertilizers.

#### Monoammonium Phosphate ( $\text{NH}_4\text{H}_2\text{PO}_4$ ).

Pure monoammonium phosphate contains 12.17 per cent Nitrogen and 61.71 per cent Phosphoric Oxide. Some fertilizer material containing 12 per cent N and 61 per cent available  $\text{P}_2\text{O}_5$  is on the market for the manufacture of liquid fertilizers and starter solutions.

The crude salt, originally sold under the trade name Ammo-phos A (11-48) is made by neutralizing crude phosphoric acid (usually made by treating phosphate rock with sulfuric acid) with ammonia and evaporating the solution.

A composite analysis of 11-48 ammonium phosphate from control bulletins follows:

Constituent	Samples Number	Min. %	Max. %	Mean %
N:				
Water-Insoluble.....	41	0.19	1.50	0.46
Total.....	264	9.54	12.60	11.27
$\text{P}_2\text{O}_5$ :				
Available.....	262	40.92	52.27	48.48
Water-soluble.....	38	35.16	46.43	43.68
Insoluble.....	176	.03	2.63	.93
$\text{K}_2\text{O}$ .....	3	.14	.33	.22
$\text{Na}_2\text{O}$ .....	4	.14	1.35	.63
$\text{CaO}$ .....	11	.40	2.80	1.51
$\text{MgO}$ .....	7	.31	.90	.46
$\text{Fe}_2\text{O}_3$ .....	10	1.90	4.52	2.24
$\text{Al}_2\text{O}_3$ .....	10	1.15	3.00	1.98
$\text{CuO}$ .....	6	.007	.043	.02
$\text{MnO}$ .....	6	.016	.10	.04
$\text{ZnO}$ .....	3	.016	.070	.042
$\text{Cl}$ .....	6	.01	.50	.10
$\text{SO}_3$ .....	9	3.40	12.46	5.59
$\text{B}_2\text{O}_3$ .....	6	.00	.30	.06
$\text{Cr}_2\text{O}_3$ .....	6	.007	.15	.05
F.....	4	tr.	.75	.19
$\text{V}_2\text{O}_5$ .....	5	.36	.49	.39
Moisture.....	70	.75	7.14	1.64

#### Diammonium Phosphate ( $(\text{NH}_4)_2\text{HPO}_4$ ).

Diammonium phosphate has an economic advantage over monoammonium phosphate, because the same amount of acid fixes twice as much ammonia. Pure salt is not stable and loses ammonia when damp. The Tennessee Valley Authority<sup>5</sup> has developed processes that produce stable products and these are being commercially developed on a large scale. The pure salt contains 21.21 per cent Nitrogen and 53.76 per cent Phosphoric oxide. The fertilizer grade material contains from 18 to 21 per cent N, and from 46 to 54.25 per cent  $\text{P}_2\text{O}_5$ .

The AAFCO official definition follows:

"Ammonium phosphate (fertilizer grade) is a product obtained when phosphoric acid is treated with ammonia and consists principally of monoammonium phosphate, diammonium phosphate or a mixture of these two salts. The guaranteed percentage of nitrogen and of available phosphoric acid shall be stated as part of the name."

**Ammono-phos**—see Ammonium Phosphate and Ammonium Phosphate Sulfate.

#### Ammonium Phosphate Nitrate.

A mixture of ammonium phosphate and ammonium nitrate. It is produced by ammoniating the solution separated from phosphate rock that has been acidulated with an excess of nitric acid. The average composition of the fertilizer is 27.43 per cent N and 15.13 per cent phosphoric oxide ( $P_2O_5$ ).

#### Ammonium Phosphate Sulfate.

A double salt of ammonium phosphate and ammonium sulfate or a mixture of these two salts. When first marketed in 1923 this material was called Ammon-phos B. It is guaranteed to contain 16 per cent N and 20 per cent available  $P_2O_5$ . It contains 45 per cent ammonium sulfate. The 13-39 grade contains around 20 per cent ammonium sulfate.

A composite analysis of 16-20 grade ammonium phosphate-sulfate follows:

Constituent	Samples Number	Min. %	Max. %	Mean %
N:				
Water-insoluble...	19	0.10	0.90	0.20
Total.....	668	15.61	17.06	16.40
$P_2O_5$ :				
Available.....	668	18.58	24.80	20.61
Total.....	548	19.75	24.92	21.06
$K_2O$ .....	2	.17	.20	.18
$CaO$ .....	6	.10	.60	.40
$MgO$ .....	2	.05	.30	.17
$Fe_2O_3$ .....	6	.80	1.00	.88
$Al_2O_3$ .....	6	.80	1.30	.97
$CuO$ .....	5	.024	.06	.03
$MnO$ .....	4	.12	.75	.30
$ZnO$ .....	2	.008	.037	.023
Cl.....	3	tr.	.60	.20
$SO_3$ .....	7	37.00	39.51	38.49
$B_2O_3$ .....	4	.00	.30	.09
F.....	2	.00	1.50	.75
Moisture.....	358	.01	1.27	.63

The AAFCO official definition follows:

"Ammonium phosphate-sulfate (fertilizer grade) is a product obtained when a mixture of phosphoric acid and sulfuric acid is treated with ammonia. It consists principally of a mixture of ammonium phosphate and ammonium sulfate. The guaranteed percentages of nitrogen and available phosphoric acid shall be stated as a part of the name."

#### Ammonium Polysulfide.

Is used as a combination fertilizer and soil acidifier. Eight samples analyzed in the Arizona Control Laboratory in 1960 contained a mean of 20.06 per cent N and 36.22 per cent S.

#### Ammonium Sulfate $((NH_4)_2SO_4$ ; Sulfate of Ammonia).

It is a white or grayish crystalline salt made by neutralizing 30-50 per cent sulfuric acid with ammonia in a saturator. The temperature of reaction is usually controlled between 240° and 245° F. The crystals are drawn off as formed, centrifuged, and dried. It was first produced in this country about 1860 as a byproduct of illuminating gas. That material was dark in color, smelled of pyridine and contained about 20.5 per cent N. Today

very large quantities are produced in byproduct coke ovens and in synthetic ammonia plants. The byproduct material averages about 20.7 per cent N and the synthetic about 21.0 per cent N. It is also produced on a small scale in the manufacture of bone black with spent acid from petroleum refining and other industries. It is also incidentally produced when overacidulated superphosphate is ammoniated.

The average N and moisture contents of samples reported by fertilizer control authorities were as follows:

Year	Nitrogen		Moisture	
	Number	Per Cent	Number	Per Cent
1880.....	36	20.58	6	1.34
1900.....	31	20.63	31	1.40
1920.....	96	20.76	27	.85
1940.....	424	20.76	59	.13
1950.....	154	20.85	17	.74
1960.....	570	20.96	124	.16

Ammonium sulfate is a major ingredient of mixed fertilizers in every region. It is also widely used as a separate fertilizer in the Western part of the country. It is seldom used on unlimed acid soils, because of its high physiological acidity (see acidity). Where sulfur is lacking in the soil or air, it is valuable for its sulfur content also.

A composite analysis of determinations reported since 1920 follows:

Constituent	Samples Number	Min. %	Max. %	Mean %
N.....	6,897	17.53	22.47	20.84
$P_2O_5$ .....	6	.00	.17	.07
$K_2O$ .....	4	.00	1.87	.47
$CaO$ .....	3	.00	1.11	.37
$CuO$ .....	3	.0003	.094	.032
$Fe_2O_3$ .....	9	tr.	.041	.018
$MnO$ .....	14	.00	.010	.001
$ZnO$ .....	10	.00	.062	.015
$SO_3$ .....	23	55.40	60.52	59.60
Cl.....	97	.05	1.92	.49
Pyridine.....	7	.00	.22	.06
Water-insoluble.....	11	.10	1.34	.57
Water of constitution.....	computed.....			13.38
Moisture.....	902	.00	4.10	.38
Free Sulfuric Acid	26	.00	.25	.12

The AAFCO official definition follows:

"Sulfate of Ammonia (Ammonium Sulfate) is chiefly the ammonium salt of sulfuric acid. It shall contain not less than 20.5% of nitrogen."

#### Ammonium Sulfate-Nitrate.

This material is a true double salt. It is much less hygroscopic than it would be if it contained ammonium nitrate. Although not produced in this country, large tonnages have been imported under the trade names Leunasalpeter and Montansalpeter.

The AAFCO official definition follows:

"Ammonium sulfate nitrate is a double salt of ammonium sulfate and ammonium nitrate which are present in equal molecular proportions. It shall not contain less than 26 per cent nitrogen, one-fourth of which is in the nitrate form and three-fourths in the ammonia form."



**Ammonium Thiosulfate.**

Liquid nitrogen-sulfur fertilizer and soil conditioner to correct sulfur deficient and alkaline soils.

**Amnical**—see Ammonium Nitrate-Limestone.

**Analysis.**

The AAFCO official definition follows:

"The word *analysis*, as applied to fertilizers, shall designate the percentage composition of the product expressed in those terms that the law requires and permits."

**Angle of Repose.**

The angle with the horizontal of the slope at equilibrium of a pile of loose material. The delivery rate of many distributors varies inversely with the angle of repose. (See Drillability).

**Anhydrite (CaSO<sub>4</sub>).**

Anhydrous calcium sulfate. It is used for the same purposes as land plaster or gypsum. A dozen samples of material used in the peanut area of North Carolina and Virginia averaged 39.91 per cent CaO and 53.9 per cent SO<sub>3</sub>.

**Anhydrous Ammonia**—see Ammonia (Liquid anhydrous).

**A-N-L**—see Ammonium Nitrate-Limestone.

**Anti-Caking Agent**—see Conditioners.

**Apatite.**

A group of calcium phosphates having the type formula  $Ca_{10}(X_2)(PO_4)_6$  where X is usually fluorine, chlorine, or the hydroxyl group either singly or together. Fluor-apatite, which is the best known of the apatites, is widely distributed as the crystalline mineral. The phosphoric oxide (P<sub>2</sub>O<sub>5</sub>) and fluorine in all commercial types of phosphate rock now produced in the United States are probably combined in the form of fluor-apatite, mixed with impurities, such as sand, clay, etc.

Crystalline fluor-apatite contains from 38.0 to 41.0 per cent phosphoric oxide (P<sub>2</sub>O<sub>5</sub>) and from 3.2 to 4.3 per cent fluorine (F). It occurs in small quantities in many parts of the world. There is a large deposit in Russia.

Calcium hydroxy-apatite or calcium hydroxy-phosphate,  $(Ca_{10}(OH)_2(PO_4)_6)$ , may be formed to a small extent in ammoniated superphosphate.

**Apparent Specific Gravity.**

Is the weight of a fertilizer divided by the weight of an equal volume of water at 40° F. All pure substances have a fixed specific gravity at a given temperature and pressure, but the apparent specific gravity varies somewhat with the state of sub-division, in other words the size and shape of the particles.

The apparent specific gravity of a liquid is the same as its density at any given temperature and pressure.

This property is of great importance, because it determines, in large measure, the rate at which a distributor setting will apply a given fertilizer to the soil, the size bag that must be used to hold a certain weight, how much can be loaded in a bin or freight car, and for other reasons, such as seg-

regation of mixtures. Fertilizer distributors dispense by volume, but farmers want to apply fertilizers by weight. Dry mixtures of materials of varying specific gravity are more likely to segregate when handled. All things equal, low apparent specific gravity is an advantage in conditioners.

Apparent specific gravity is roughly determined by weighing one pint and dividing the result in ounces by 16, or by weighing one liter in kilograms to 2 decimal places.

Determinations made at normal room temperature and pressure on from 1 to 200 samples of each material during the 1930's give the following averages:

	Mean Ap. Sp. Gr.
Ammonia, anhydrous.....	0.62
Ammonia, aqua .....	.95
Ammoniated Superphosphate.....	.99
Ammonium nitrate, gran. ....	.86
Ammonium nitrate, prilled.....	.95
Ammonium nitrate-limestone.....	1.03
Ammonium nitrate solution.....	1.31
Ammonium phosphate (11-48).....	.86
Ammonium phosphate-sulfate (16-20).....	.85
Ammonium sulfate.....	.87
Basic slag, open-hearth.....	2.30
Blood, dried.....	.80
Bone meal, raw.....	.88
Borax.....	.73
Calcium cyanamide, gran. ....	.95
Calcium cyanamide, pulverized.	.83
Calcium nitrate.....	.99
Cocoa shells .....	.48
Coffee chaff.....	.12
Cork dust.....	.38
Cottonseed meal .....	.66
Diammonium phosphate.....	.73
Diatomaceous earth.....	.25
Dolomite.....	1.53
Fish emulsion.....	1.22
Fish scrap, dried.....	.49
Furfural waste .....	.51
Fused tricalcium phosphate.....	1.25
Garbage tannage.....	.64
Guano, Peruvian .....	1.20
Lime, hydrated .....	.48
Limestone, finely ground.....	1.60
Lime sulfur solution .....	1.32
Manure, dried sheep & cattle...	.39
Manure, dried poultry.....	.66
Manure salts, New Mexican.....	1.15
Mixed fertilizers, liquid.....	1.30
Mixed fertilizers, N-K .....	.94
Mixed fertilizers, N-P-K.....	.97
Mixed fertilizers, P-K .....	1.07
Mixed fertilizers, granular .....	.92
Magnesium sulfate, calcined kieserite.....	1.40
Magnesium sulfate, epsom salt.	.81
Nitrogen solutions, ammonia and ammonium nitrate.....	1.20
Nitrogen solutions, urea and ammonium nitrate.....	1.32
Peanut hull meal.....	.50
Peat moss .....	.22
Peat, reed and sedge.....	.78
Perlite.....	.13
Phosphate rock, Fla. land pebble.....	1.28

	Mean Ap. Sp. Gr.
Phosphoric acid.....	1.69
Potassium chloride.....	1.02
Potassium nitrate.....	1.03
Potassium sulfate.....	1.40
Precipitated phosphate.....	.81
Rice hulls .....	.22
Sewage sludge, activated.....	.68
Sodium nitrate.....	1.25
Sulfate of potash-magnesia.....	1.36
Superphosphate, 18-20%.....	.91
Superphosphate, 42-48%.....	.96
Tankage, animal.....	.69
Urea, crystal .....	.57
Urea, pellet .....	.66
Urea-form.....	.45
Vermiculite, exfoliated.....	.26
Wood ashes.....	.77

The standard deviation on the above determinations is about 0.1. Since these determinations were made, new methods of production have been introduced for certain materials. For example, some hard granulated ammonium sulfate has an Ap. Sp. Gr. of 1.00, or even slightly higher. Some materials pack down under pressure. Thus a large pile of such material has a higher apparent specific gravity than a small one.

**Artificial Manure**—see Compost.

**Association of American Fertilizer Control Officials (AAFCO).**

The membership of the Association shall consist of:

(1) The officers charged by law with the active execution of the laws regulating the sale of commercial fertilizer and fertilizer materials.

(2) Such deputies as shall be duly designated by the officials named under (1) of this section.

(3) Research workers employed by State, Dominion or Federal agencies who are engaged in the investigation of fertilizers.

Since 1948, the AAFCO has taken the place of the Committee on Definitions of Terms and Interpretation of Results of Fertilizers of the AOAC. Decisions of the AAFCO are final and are not referred to the AOAC for approval. It publishes an annual bulletin giving the official regulations and interpretations, many of which are reprinted here.

#### AOAC

*Association of Official Agricultural Chemists (of North America).* Analytical chemists connected with the U. S. Department of Agriculture, or with any State, provincial or national agricultural experiment station or agricultural college, or with any State, provincial or national institution or body in North America charged with official control of fertilizers, and other agricultural materials, shall be eligible *ex officio* to active membership. Analytical chemists connected with municipal laboratories charged with control of any of the materials named above shall be eligible *ex officio* to associate membership.

The objects of the association shall be:

(1) To secure uniformity and accuracy in the methods, results and models of statement of analysis of the materials above mentioned.

(2) To afford opportunity for the discussion of matters of interest to agricultural chemists.

Only active members of this association shall have a vote in its decisions and only one vote for

each institution (college, experiment station, bureau, etc.), and each institution shall be entitled to vote only upon questions relating to those materials over which said institution exercises official control. (See Association of American Fertilizer Control Officials.) (AAFCO).

**A. S. N.**—see Ammonium Sulfate-Nitrate.

**Availability of Nitrogen or Ammonia**—see Activity of Water Insoluble Nitrogen in Mixed Fertilizers.

#### Available.

This term as applied to each of the three primary fertilizer constituents, nitrogen, phosphoric oxide and potash, has somewhat different meanings. In each case all that is soluble in water is available. In addition, however, some of each that is not soluble in water is available to plants.

It is preferable to use the terms active and inactive as applied to insoluble nitrogen, unless the results of actual field or growing tests can be used. Animal and vegetable materials may decompose in damp, warm soils and part or all of the nitrogen thus becomes available to growing plants. Some of the nitrogen may, however, remain unavailable. In order to anticipate the relative value of the nitrogen contained in organic (animal or vegetable) materials empirical laboratory methods have been developed which give results in reasonable agreement with field tests.

Available phosphoric oxide in ammonium phosphates, superphosphates, or mixed fertilizers, is the water soluble plus the ammonium citrate-soluble phosphoric oxide. In practice a weighed portion of sample is washed with water and the residue is treated with neutral ammonium citrate solution. The difference between the amount remaining in the residue and the total is the available.

For basic slag, fused phosphates, calcium metaphosphate and rock phosphates the available  $P_2O_5$  is determined as the part soluble in a 2 per cent citric acid solution.

Available potash is considered to be that which is soluble in water, or in a solution of ammonium oxalate.

Official methods of analysis for determining the availability of fertilizer nutrients have been adopted by the AOAC (which see). Available plant food is intended to mean that which is in a form capable of being assimilated by growing plants or of being converted into such a form in the soil during the growing season.

The AAFCO official definition follows:

"Available phosphoric acid is the sum of the water-soluble and the citrate-soluble phosphoric acid."

**B Liquor**—see Ammonia Liquor.

#### Base Goods (Dry Mix).

A mixture of several fertilizer materials, usually superphosphate, with materials containing ammonia or potash or both. This mixture, after curing, is used as a base in making fertilizer mixtures.



**Base Goods (Wet Mix).**

This term denotes a product made by treating phosphate rock and some organic nitrogenous substance with sulfuric acid. Hair, leather scrap, beet residues, wool waste, feathers, garbage tankage, dead animals, and spoiled meat or fish are the organics commonly used. The acid converts the inactive nitrogen and phosphate to available forms. It is a means of recovering the fertilizer value of substances that otherwise could not be marketed. Base goods is made with the same equipment used for making superphosphate.

As usually made it contains from 2 to 5% N and 14 to 18% available  $P_2O_5$ .

**Basic Lime Phosphate.**

Originally offered as a substitute for basic slag, it is no longer used in important amounts.

The AAFCO official definition follows:

"'Basic' lime phosphate (lime-based superphosphate) is a superphosphate to which liming materials have been added in a quantity at least six per cent (6%) calcium carbonate equivalent in excess of the quantity required to convert all water-soluble phosphate to the citrate-soluble form."

**Basic Slag (Thomas Slag; Thomas Phosphate).**

A byproduct produced in the manufacture of steel from phosphatic iron ores or pig iron by the Thomas process. It is the principal phosphatic fertilizer in some European countries, but is not made here. Some is imported, however.

The principal component is silicocarnotite ( $5CaO \cdot P_2O_5 \cdot SiO_2$ ). It usually also contains calcium tetraphosphate ( $Ca_4P_2O_9$ ) and other compounds.

The results of analyses published since 1920 are summarized as follows:

Constituent	Samples Number	Min. %	Max. %	Mean %
$P_2O_5$				
(citric acid-sol.)...	189	10.00	17.50	15.59
$P_2O_5$ (total).....	345	11.10	23.36	17.64
CaO.....	35	38.46	50.40	46.46
MgO.....	51	2.31	15.07	6.86
CuO.....	3	.0012	.0016	.0014
MnO.....	40	.21	7.66	4.44
ZnO.....	3	.0004	.0012	.0007
$B_2O_3$ .....	5	.0015	.013	.0067
Iron oxides.....	9	8.03	21.46	14.38
$Al_2O_3$ .....	3	1.03	4.57	3.39
Fluorine.....	4	.05	.10	.07
$MoO_3$ .....	3	.0004	.0011	.0006
Sulfur.....	2	.15	5.80	2.98
Silica ( $SiO_2$ ).....	13	4.65	18.64	7.77
Moisture.....	48	.01	.63	.35

The AAFCO official definition follows:

"Basic phosphate slag is a byproduct obtained in the manufacture of steel from phosphatic iron ores. The product shall contain no admixture of materials other than those resulting from the original process of manufacture. It shall contain not

less than twelve percent of total phosphoric acid, of which at least 80 per cent shall be available phosphoric acid. It shall be ground so that not less than 70 per cent of the material passes through a U. S. Standard No. 100 sieve and 90 per cent passes through a U. S. No. 50 sieve. Any not conforming to this definition shall be designated *low grade*."

**Basic Slag, Open-hearth**

It is produced in large quantities at Birmingham, Ala. in the open-hearth steel process. A summary of analyses published since 1935 follows:

Constituent	Samples Number	Min. %	Max. %	Mean %
$P_2O_5$ (citric acid sol.)	89	7.40	12.45	10.19
$P_2O_5$ (total)	297	8.20	13.75	11.88
CaO	44	34.50	49.52	40.54
MgO	31	4.12	7.40	5.69
CuO	10	.0011	.0044	.0020
MnO	15	1.86	4.47	2.86
ZnO	10	.0012	.0036	.0025
$B_2O_3$	26	.002	.010	.0054
Iron and Al. oxides	7	18.50	24.78	22.29
Fluorine	3	.14	.37	.28
$MoO_3$	10	.0014	.0016	.0015
Sulfur	1			.32
Silica	1			8.00
Moisture	2	.03	.17	.10

**Bat Guano—see Guano.**

The AAFCO has the following official definition:  
"Bat guano is partially decomposed bat manure."

**Bay-Sol—see Nitrogen Solutions.****Beet Sugar Residue (Beet Slop).**

The liquid product resulting after the beet sugar has been extracted. This liquid contains from 3 to 4 per cent nitrogen, and from 8 to 10 per cent potash ( $K_2O$ ). It is often used in making wet-mixed base.

**Bird Guano—see Guano.****Blast Furnace Slag.**

Finely divided slags produced from coke, dolomite, and iron ores low in phosphorus usually have a soil liming value similar to that of ground limestone. About 100,000 tons are used annually as a liming material.

The average CaO content of 316 samples is 41.02 (26-4-50.8) per cent and the MgO is 6.34 (1.49-19.43) per cent. The  $P_2O_5$  runs from 0.007 to 3.21 per cent. Like basic slag this material also contains relatively large quantities of all the trace nutrients.

**Blood.**

One ton of dried blood is obtained from approximately every 300 cattle slaughtered. Since 1925 over 90 per cent of the production has gone into hog and poultry feed. The poorer grades are used

for fertilizers. The nitrogen of blood quickly becomes available to crops.

A summary of analyses published since 1920 by fertilizer control offices follows:

Constituent	Samples Number	Min. %	Max. %	Mean %
N	1076	7.65	14.55	12.91
P <sub>2</sub> O <sub>5</sub>	169	.04	10.28	1.50
K <sub>2</sub> O	5	.11	.87	.57
CaO	6	.16	.55	.34
MgO	4	.08	.36	.17
CuO	5	.0004	.0016	.0009
MnO	4	.0001	.0012	.0005
ZnO	2	.001	.004	.003
SO <sub>3</sub>	2	.15	.70	.42
B <sub>2</sub> O <sub>3</sub>	1	....	....	.0032
Iodine	2	.0001	.0002	.0002
Organic matter	6	83.59	87.72	85.16
Moisture	514	2.30	18.59	9.32

The AAFCO official definition follows:

"Dried blood is the collected blood of slaughtered animals, dried and ground, and containing not less than 12 per cent of nitrogen in organic forms."

#### Bone Black, Spent.

When bones are heated in closed retorts, similar to those used for making coke from coal, the residual charcoal is known as bone black. It is used for refining sugar and oil. After the bone black has been used for some time it becomes unfit for this use and is sold as "spent" bone black to feed or fertilizer manufacturers.

Eleven samples of fertilizer grade material contained an average of 0.63 per cent N, 32.55 per cent P<sub>2</sub>O<sub>5</sub>, 0.62 per cent K<sub>2</sub>O, 38.58 per cent CaO,

1.26 per cent MgO, and 13.62 per cent organic matter. The K<sub>2</sub>O was run on only two samples and the MgO on three.

#### Bone Meal (Raw).

Meal made from animal bones cooked in open vats to remove meat and fat is called raw bone meal. It is important to grind the bone meal fine, as its availability as a plant food depends largely upon the fineness.

The N content of 1945 samples analyzed in control laboratories since 1920 averaged 3.87 (2.01-6.34) per cent. The P<sub>2</sub>O<sub>5</sub> averaged 22.46 (15.30-27.25) per cent. The mean CaO content of 44 samples is 30.68 (23.8-35.0) per cent. It always contains minute amounts of the trace nutrients.

The AAFCO official definition follows:

"Ground raw bone is ground animal bones that have not been previously steamed under pressure."

#### Bone Meal (Steamed).

When steamed under pressure some of the cartilage in bones is converted to gelatine and dissolved. The steamed bones are soft and chalky-like in character which makes them more quickly available as fertilizer material.

The mean N and P<sub>2</sub>O<sub>5</sub> contents of 1566 samples of steamed bone meal reported by state control offices are 2.24 (0.7-4.3) per cent and 27.42 (18.34-34.56) per cent, respectively. The CaO average of 45 samples is 35.26 (23.69-45.62) per cent. Of 86 samples subjected to screen tests since 1940, an average of 73.2 per cent passed a 50-mesh sieve.



The AAFCO official definition follows:

"Ground steamed bone is ground animal bones that have been previously steamed under pressure."

**B. P. L. (Bone Phosphate of Lime)**—see Calcium Phosphate.

#### Bones.

A good supply of bones comes from junk collectors and small abattoirs and butchers. These bones have flesh and fat sticking to them and are degreased before being ground. Bones, raw or steamed (which see), are always finely ground before being applied to the soil. Formerly ground bones were the principal source of phosphoric oxide. Today most of the bone meal produced is used in the manufacture of feeds, but substantial quantities are sold to home gardeners, especially for growing roses and other flowers.

**Borax** ( $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ ).

A white crystalline material used in fertilizers to supply the essential element Boron.

Impure borax occurs as kemite in crystalline masses and this together with tincal, colemanite, ulexite, and certain brines, are the sources from which refined borax is produced.

Pure Borax contains 11.34% elemental boron (B) or 36.5% boric oxide ( $\text{B}_2\text{O}_3$ ). Borax is efflorescent and thus often contains less water of crystallization than theoretical. Twenty-four samples of fertilizer grade material averaged 11.70 (10.5-14.9) per cent B, or 37.64 (33.65-47.92) per cent  $\text{B}_2\text{O}_3$ .

Polybor 2 and Solubor are the trade names for sodium borate that contains 20.5% B or 66%  $\text{B}_2\text{O}_3$ . It is prepared especially for fertilizer use and is equivalent to 180% borax. Tronabor is the pentahydrate ( $.5 \text{ H}_2\text{O}$ ). It contains about 14.5% B, or 46.7%  $\text{B}_2\text{O}_3$ .

#### Boron (B).

Boron is an essential mineral element known to be required in trace amounts for growth of some plants, especially the legumes. It does not occur in pure form but is commonly found as the oxide in combination with sodium or calcium. (See Borax and Colemanite).

#### Brand and Brand Name.

The AAFCO has adopted the following definitions and interpretations:

"A brand is a term, design or trade-mark used in connection with one or several grades of fertilizer."

"A brand name is a specific designation applied to an individual fertilizer."

(6) W. Scholl, M. M. Davis and C. A. Wilker, "Solid and Liquid Fertilizer Distribution in Bulk in the United States, Years Ended June 30, 1954 and 1959." Official Pub. AAFCO 14:59-66 (1960).

"The grade of a fertilizer should be included with its brand name, and so used by the manufacturer on sacks and in printed literature and by the control official in his reports and publications. No numeral shall be used in the brand name or grade of a commercial fertilizer except those referring to nitrogen, available phosphoric acid and potash."

"When the name of a fertilizer material is used as a part of the brand name of a mixed fertilizer, as for example blood, bone or fish, the nitrogen or phosphoric acid shall be derived from or supplied entirely by the material named. When the name of a fertilizer material is used as a brand or as a part of a brand and the nitrogen and phosphoric acid is not supplied by the material named, the word 'brand' shall follow the name of the materials. Example: 'Fish Brand Fertilizer.'"

**Brimstone**—see Sulfur.

#### Brucite.

A natural mineral, magnesium hydroxide ( $\text{Mg}(\text{OH})_2$ ). When this material is calcined, magnesium oxide (magnesia)  $\text{MgO}$  remains. Calcined brucite contains an average of 74 (65-80) per cent  $\text{MgO}$ .

#### Buffer Capacity of Soils.

The ability of a soil to resist a change in its hydrogen-ion concentration, or to resist the tendency to become more acid upon the addition of an acid (or an acid-forming material) or more alkaline upon addition of a base (or a base-forming material).

#### Bulk Fertilizer.

In 1961, bulk shipments constituted 25.9 per cent of total shipments, as compared with 10.6 per cent in 1954. Solids were 15.0 per cent, and liquids were 10.9 per cent of total shipments in 1961.<sup>6</sup>

The AAFCO official interpretation follows:

"The term *bulk fertilizer* shall mean commercial fertilizer delivered to the purchaser, either in the solid or liquid state, in a non-packaged form to which a label cannot be attached."

#### Caking.

Is a process by which a fertilizer loses its desirable free-flowing property. The principal reason for caking is change of moisture content.

When damp fertilizers are dried, the salts that were in solution in the film of moisture on the surfaces of the particles are crystallized. These crystals adhere tightly and tend to knit the particles together. Plastic substances cake under pressure. Chemical reactions between ingredients of a mixture may also cause severe caking.

Caking can be prevented or lessened by granulation, maintenance of low moisture content in the fertilizer at all times, or by coating the particles with insoluble inert materials (conditioners, which see).

**Calcined Brucite**—see Brucite.

**Calcined Dolomite**—see Selectively Calcined Dolomite.

**Calcined Magnesite**—see Magnesite.



### Calcined Phosphate.

A general term for several materials produced by heating phosphate rock, with or without reagents. Simply heating to 1520° in a rotary kiln destroys all organic matter, converts the calcium carbonate to the oxide, and drives out some of the fluorine. This calcined phosphate is used in the manufacture of high-grade phosphoric acid. When heated with silica and moisture to 2700° the fluorine is almost entirely expelled and the apatite is converted to tricalcium phosphate. This product is the fertilizer also known as Fused Tricalcium Phosphate. It contains about 24 per cent  $P_2O_5$  available by the 2 per cent citric acid method. A similar product is sold to the feed trade as defluorinated phosphate.

Calcined phosphate, as made by the Loyd, Newberry, or Kreiss Process, is obtained by heating rock phosphate with salt, potassium chloride, or potassium sulfate, respectively. Rhenania phosphate, which contains around 25 per cent available  $P_2O_5$ , and is widely used in Germany, is a calcined phosphate of this character.

When rock phosphate is calcined with serpentine or olivine a glass is produced that contains 18-19 per cent available  $P_2O_5$  by the 2 per cent citric acid method. Thermo-Phos and M-P Phosphate are trade names of commercial fertilizers of this kind that have been produced in the Pacific Region.

### Calcium (Ca).

This is a hard, brittle metal which is too reactive to use in its elemental state. We are familiar with its oxide (lime) and with the various salts. It is essential for plant growth and is one of the secondary fertilizer elements (see Secondary Fertilizer Nutrients).

### Calcium Ammonium Nitrate.

A trade name for an ammonium nitrate limestone mixture, made in Europe.

The AAFCO official interpretation follows:

"This Association recommends the disapproval of the registration of mixtures of ammonium nitrate and limestone or dolomite under the names—'Ammonium calcium nitrate,' 'Calcium ammonium nitrate' and similar names which imply the presence of either calcium nitrate or ammonium carbonate in such mixtures."

### Calcium Carbonate ( $CaCO_3$ ; Carbonate of Lime).

Limestone, marble and oyster shells are composed largely of calcium carbonate. In such forms it is extensively used to neutralize soil acids. It is also a principal component of dolomite.

Pure Calcium Carbonate contains:

Lime (CaO).....	56%
Carbon Dioxide ( $CO_2$ ).....	44%

(7) A. B. Phillips, R. D. Young, J. S. Lewis, Jr., and J. Silverberg, "Calcium Metaphosphate in Fertilizers." Agr. and Food Chem. 5: 839-844 (1957).

### Calcium Cyanamide ( $CaCN_2$ ).

It is manufactured by heating lime and coke to 4000° in an atmosphere of nitrogen. Most of the calcium cyanamide used in the United States has been imported from Niagara Falls, Canada.

Calcium cyanamide is poisonous and irritating to the skin and mucous membranes and should be washed off promptly. In acid solutions and in most soils it hydrolyzes to urea. In pure water or alkaline solutions it may polymerize to dicyandiamide.

The commercial products are sold under the trade name "Cyanamid." Cyanamid is guaranteed to contain 21 per cent N, which corresponds to 60 per cent  $CaCN_2$ . About 2 per cent of the nitrogen, however, is in the form of other compounds. The average N content of 2050 samples reported in control bulletins from 1920 to 1960 is 21.77 (17.58-23.70) per cent. It also contains about 5 per cent oil to prevent dustiness, 12 per cent graphite, about 19 per cent calcium hydroxide, and 6 per cent calcium carbonate.

The following are the official AAFCO definition and interpretation:

"Cyanamid is a commercial product consisting principally of calcium cyanamid ( $CaCN_2$ ) and carbon and it shall contain not less than twenty per cent (20%) of nitrogen."

"The nitrogen in Cyanamid and urea is synthetic non-protein organic nitrogen."

Calcium Hydroxide—see Hydrated Lime and Liming Materials.

Calcium Hydroxy-Phosphate—see Apatite.

Calcium-Magnesium Phosphate—see Fused Calcium-Magnesium Phosphate.

### Calcium Metaphosphate ( $Ca(PO_3)_2$ ).

The pure salt contains 28.32 per cent CaO and 71.68 per cent  $P_2O_5$ .

It is a glassy material produced by burning phosphorus vapors from an electric furnace in contact with phosphate rock. The fertilizer grade contains 62-65 per cent citric-acid-soluble  $P_2O_5$  and 25 per cent CaO. The mean available  $P_2O_5$  content of 65 samples analyzed in 1960 by various control laboratories is 63.42 per cent. It is only slightly soluble in water, but is equal to superphosphate in promoting crop yields in neutral or acid soils. The TVA production is distributed under the trade name Metaphos.

A process has been developed recently for ammoniating and granulating it into mixed fertilizers.<sup>7</sup> The metaphosphate is first hydrolyzed with mineral acid to produce the orthophosphate.

The AAFCO has the following official definition.

"Calcium metaphosphate is a vitreous product substantially free from crystalline phosphates, resulting from the treatment of phosphate rock with gaseous phosphorus pentoxide at high temperatures. The guaranteed percentage of available phosphoric acid shall be stated as part of the name." (see also under Phosphates).

**Calcium Nitrate** ( $\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$ )

The calcium salt of nitric acid. This material has been produced in large quantity in Europe.

Material now being imported is made by treating limestone with synthetic nitric acid until it all dissolves and then neutralizing with ammonia. A double salt separates with the composition  $5\text{Ca}(\text{NO}_3)_2 \cdot \text{NH}_4\text{NO}_3 \cdot 10\text{H}_2\text{O}$ . Before bagging it is partially dehydrated and pelleted by melting and spraying in dry air. It does not become sticky until fully hydrated. After that, if exposed to the air it may completely liquefy. Its hygroscopic point at  $86^\circ$  is a relative humidity of only 46.5 per cent. Therefore when a bag is opened it should be used as soon as practical.

Pure anhydrous salt contains 17.1 per cent N and 34.2 per cent CaO.

The mean N content of 301 samples analyzed in U. S. control laboratories is 15.43 (14.39-16.11) per cent. It also contains 27.24 per cent CaO and 2.49 per cent MgO on the average.

The AAFCO official definition follows:

"Calcium nitrate is chiefly the calcium salt of nitric acid. It shall contain not less than fifteen per cent (15%) nitrate nitrogen."

**Calcium Nitrate-Urea** ( $\text{Ca}(\text{NO}_3)_2 \cdot 4\text{CO}(\text{NH}_2)_2$ ).

As crystallized from solution this material consists of calcium nitrate with four molecules of urea of crystallization, replacing the water of crystallization. It has been imported since 1928 under the trade name Calurea.

The mean N content of 73 samples is 33.78 (30.06-34.68) per cent, of which 80 per cent is in the urea form and 20 per cent in nitrate. The average CaO content is 13.11 per cent.

**Calcium Oxide** (CaO)—see Lime and Liming Materials.**Calcium Phosphate**—see also Calcium Metaphosphate.

The phosphatic part of good superphosphate consists largely of monocalcium phosphate,  $\text{CaH}(\text{PO}_4)_2$ , which is water soluble. Precipitated bone is largely dicalcium phosphate,  $\text{Ca}_2\text{H}_2(\text{PO}_4)_2$ , which is citrate-soluble. Bone meal contains calcium phosphate-carbonate,  $3\text{Ca}_3(\text{PO}_4)_2 \cdot \text{CaCO}_3$ . Apatite (which see) is calcium fluorophosphate or chlorophosphate, and phosphate rock usually contains a complex calcium fluorophosphate.

**Calcium Sulfate** ( $\text{CaSO}_4$ )—see Anhydrite and Gypsum.**Caliche.**

Mineral ore found in the desert of northern Chile, from which natural nitrate of soda is derived.

**Calmonite**—see Ammonium Nitrate-Limestone.**Cal-Nitro**—see Ammonium Nitrate-Limestone.**Calurea**—see Calcium Nitrate-Urea.**Carbon Bisulphide** ( $\text{CS}_2$ ).

A highly inflammable colorless liquid, boiling at  $115^\circ$  F. Used for degreasing seed meals, such as castor, cottonseed, etc.

**Carbon Dioxide** ( $\text{CO}_2$ ).

A gas formed by the oxidation of carbon or by the burning of coal or any material containing carbon. It combines with calcium, and the other metals to form carbonates, for example limestone. Carbonic acid ( $\text{H}_2\text{CO}_3$ ), of which  $\text{CO}_2$  is the anhydride, chemically is a very weak acid, and is replaced in its salts by the stronger acids, such as sulfuric, phosphoric, and nitric.

**Carbonate of Potash**—see Potassium Carbonate.**Carbonic Acid** ( $\text{H}_2\text{CO}_3$ ) ( $\text{CO}_2 \cdot \text{H}_2\text{O}$ )—see Carbon Dioxide.**Carnallite** ( $\text{MgCl}_2 \cdot \text{KCl} \cdot 6\text{H}_2\text{O}$ ).

Commercial muriate of potash was formerly extracted from this material in Germany, France, and Russia, but has never been in the United States. It occurs in certain U. S. deposits, but contains an average of only 9.8 per cent  $\text{K}_2\text{O}$ .

**Castor Pomace.**

The ground residue of castor beans, from which the oil has been extracted.

Practically the entire production since 1862, plus some imports, has been used as fertilizer. It is never used as feed, because its ricin content makes it poisonous to animals.

A composite analysis of determinations made since 1920 follows:

Constituent	Samples Number	Min. %	Max. %	Mean %
N:				
Ammonia.....	36	0.00	0.31	0.06
Nitrate.....	36	.12	.35	.18
Soluble				
organic....	26	.20	.56	.34
Active insol.	7	2.31	2.92	2.75
Total.....	1,498	4.15	6.64	5.20
$\text{P}_2\text{O}_5$ :				
Available.....	34	.60	2.70	1.83
Total.....	215	.37	2.90	1.81
$\text{K}_2\text{O}$ .....	212	.36	1.66	1.09
CaO.....	13	.10	1.08	.58
MgO.....	11	.13	.88	.53
Iron and Al.				
oxides.....	4	.19	3.10	1.21
CuO.....	7	tr.	.05	.006
MnO.....	7	.02	.19	.05
$\text{MoO}_3$ .....	5	.001	.01	.003
ZnO.....	5	.03	.08	.06
$\text{B}_2\text{O}_3$ .....	10	.0016	.096	.042
Org. matter.....	9	78.79	86.95	93.61
Moisture.....	333	3.81	13.75	9.55
Ash.....	12	4.75	14.65	8.89