THE METAL ANALYSIS OF DOG FOOD

By

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An Honors Project submitted to the University of Indianapolis Strain Honors College in partial fulfillment of the requirements for a Baccalaureate degree "with distinction." Written under the direction of Dr. Brad Neal.

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First Reader

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Second Reader

Abstract

Packaged dry kibble is the main source of nutrients for most household dogs. As such, it is important that kibble contains proper amounts of various metals necessary for biological functions including ATP production, maintaining the proper biochemical gradient across cell membranes, and respiration. Therefore, the concentrations of specific metals in various brands of dog food were analyzed using the microwave plasma – atomic emission spectrometer (MP-AES) via an adapted methodology that can now be applied to future, similar undergraduate research projects. Because of their critical roles in maintaining the functionality of the body, sodium, potassium, magnesium, iron, and calcium were chosen to be the focus of this study. The elemental concentrations determined by the methodology using the MP-AES were compared to the accepted concentration guidelines put forth by the American Association of Feed Control Officials (AAFCO). Based on the importance of each metal and how closely each food's concentration of metals compared to the AAFCO recommended values, the dog foods were assessed.

Acknowledgment

I would like to provide a big thank you to my project advisor, Dr. Brad Neal. His instruction and dedication has been instrumental both in completing this project and in my personal growth throughout my years at the University of Indianapolis. I would also like to thank Dr. Levi Mielke and the rest of the Chemistry Department for their support and guidance throughout this process. My gratitude is also extended to Dr. John Langdon and the Undergraduate Research Fund for their financial support during the course of this project. Lastly, I would like to thank my family and friends for their prayers and support, not only while I was completing this project, but throughout my entire life.

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Statement of Purpose

Several different minerals are necessary in trace amounts for vital canine bodily functions. However, if those minerals are too abundant in a dog's diet, the minerals can start causing more harm than good. Some minerals, such as copper, iron, and manganese, are labeled on the majority of dog food bags, but other minerals, such as chromium, nickel, and cadmium, are commonly left off of the labels and still found in the dog food.[1] That said, not all dog foods are created using the same ingredients or in the same ways. Different dog food companies use varying techniques and ingredients to create a product that is unique and marketable. Examining just how unique each of these dog food brands are was the main focus of this project. While examining the health benefits was out of the scope of this project, the chemical makeups of the different types of dog food were evaluated. An additional product of this project was the creation of a method to analyze future food samples by undergraduate students conducting similar research.

Introduction

Just like humans, animals have specific nutritional requirements that must be met for them to live long, healthy lives. The Association of American Feed Control Officials (AAFCO) is an organization that determines nutritional standards for animal feeds across the United States. AAFCO produces literature on the nutritional standards that should be upheld in pet foods.[2] It is the responsibility of the companies that produce dog food to uphold the standards produced by AAFCO.

Because of this, commercial pet food companies take great care in producing safe and nutritionally well balanced foods to their customers. These companies use ingredients that provide the protein, fat, minerals, carbohydrates, fiber, and vitamins that an animal needs for normal bodily functions.[3] In all types of food, canned, dry, or semi-moist, commercially produced dog food undergoes rigorous sterilization techniques. Dr. S. Zicker, a veterinarian with a PhD in nutrition, explained that the dog food companies spend much effort "toward producing products that not only meet nutrient targets but that are also safe for their intended purposes."[4] However, because large companies have limited amounts of time and resources, sometimes contaminated dog food will unknowingly make it to the market. This can cause many adverse and even life-threatening effects on the pets that consume them.

One such incident occurred in 2007 and resulted in many pets developing renal toxicity.[3] R. L. Dobson, et al. were assigned to discover the contaminant that caused many brands of pet foods to be recalled. High-performance liquid chromatography and mass spectrometry were used to analyze the components of the dog foods. Melamine and

cyanuric acid were both identified as contaminants in the recalled pet foods and the researchers identified that an interaction between those two components as the most likely cause of the renal failure in the affected animals.[5] In 2014, Pedigree recalled several bags of dog food due to a possible contamination of an unspecified metal. The bags of Adult Complete Nutrition dog food were sold in multiple states, which complicated the recall. Mistakes like this one cost Pedigree thousands of dollars and endangered the lives of hundreds of pets.[6]

Common Minerals Found in Dog Foods

The concentrations of metals in dog foods must remain within a tight range in order to keep the pet as healthy as possible. The minimum amount required of a certain mineral can also change over time based on the age and activity level of the pet according to AAFCO.[7] Having a dietary deficit of a crucial metal can cause a multitude of health effects on an animal. For example, the cause of canine epilepsy, a disease characterized by uncontrollable seizures, has been partially attributed to deficiencies in zinc, calcium, and magnesium.[8] A deficiency of iron can lead to anemia and possibly even cognitive defects in canines.[9] While certain breeds may have genes that cause their mineral tolerance levels to be lower than average, such as certain Bedlington Terriers who often develop liver cirrhosis or die prematurely due to their livers removing copper at a slower than average rate,[10] most need concentrations within the same range. AAFCO provides general guidelines for dog food companies to follow in order for them to provide the best nutrition for the majority of dogs.[11] Too much of a particular metal can also cause adverse health effects. For example, an excess of lead in a dog's diet can lead to lead

poisoning and can cause severe symptoms including, but not limited to, convulsions, vomiting, and hysteria.[12] Because lead is not listed on pet food labels, there is no way for pet owners to know how much their animal is getting from the food and this can cause serious issues.

Copper, iron, and manganese are all minerals that should be present in dog food in trace amounts. In a study of the concentrations of trace elements produced by A. Duran, M. Tuzen, and M. Soylak, dog foods commercially available in Turkey had a mean concentration of 6.22 µg/g of copper, concentrations between 23.9 and 71.1 µg/g of iron, and a mean concentration of 8.64 µg/g of manganese. All of these values fell within the AAFCO guidelines and were listed on the food label, but other trace metals were also found in these samples. Lead, nickel, and chromium are just a few metals that are not required to be listed on pet food labels and were found in varying amounts in this study.[1]

Iron, calcium, magnesium, sodium, and potassium are all metals that play important roles in a canine's body. Calcium is critical for bone development and plays a large role in muscle and nerve function.[13] The actin and myosin in muscles would be unable to interact correctly without the proper flow of calcium through the cell.[14] Several types of epithelial cells are also dependent on calcium ions to allow cadherins to form the dimers that are critical in cell to cell adhesion.[15] While it is rare that a dog would ingest an overabundance of calcium just from its dog food, an excess of this micronutrient can cause polydipsia (excessive thirst), lethargy, depression and, in severe cases, bladder stones or hypertension.[16]

While calcium allows muscles to contract and nerve impulses to be propagated throughout the body, magnesium plays a critical role in dampening the muscle and nerve impulses. Magnesium also functions in reactions involving the formation of adenine triphosphate (ATP) which is the body's main source of energy.[13] Dogs lacking in magnesium tend to have excessive calcification of the heart and arteries found throughout the body, which can negatively affect blood flow. The heart can also be affected by an excess of magnesium. Too much magnesium shrinks the lipid deposits protecting the heart and can lead to other severe heart problems.[17]

Sodium is arguably the most important extracellular ion with its function in maintaining the proper water balance of the body. Its role in maintaining the electrical potential across cell membranes is especially important in the flow of nerve and muscle cell impulses throughout the body.[13] There are also many ion pumps throughout the body that rely on sodium for proper functionality. Salt poisoning has little to no effect on the body as long as the animal has constant access to fresh water. However, without enough water, excessive salt intake has been known to cause severe vomiting, muscle tremors, and seizures.[18]

Potassium assists sodium in the maintenance of cell electrical potential. For this reason, fairly constant levels of potassium are needed in the body at all times to maintain the functionality of the various sodium/potassium pumps throughout the body. Paralysis of muscles and disruption of proper cardiac function are both side effects of having too little potassium in the body.[13] Dogs suffering from hyperkalemia, or excessive potassium, can have minor symptoms such as depression or weakness throughout the

body. However, in severe cases of hyperkalemia, dogs can suffer from cardiac arythmias.[19]

A micronutrient that is essential for almost all living organisms is iron. Iron acts as a co-factor for many proteins that have crucial life sustaining roles. In dogs, as well as other vertebrates, iron plays a critical role in cell division as well. Without iron, it would be very difficult for the body to maintain functionality.[13] An overdose of iron has severe effects on the body, by first causing gastrointestinal trauma, then shock and tachycardia, and, in severe cases, death.[20] Because of the severity of iron toxicity and the important roles that iron plays in day to day functionality, it can be argued that iron is the most important micronutrient.

Various Instruments and Digestion Techniques

Many different instruments have been used to analyze the different components of dog food. The most common method of determining the concentrations of trace elements involves flame atomic absorption spectroscopy, which is directly related to microwave plasma atomic emission spectroscopy. However, most of these instruments require samples to be in an aqueous in order to be analyzed. Therefore, digestion of solid compounds is necessary for analysis. Several different digestion methods are proposed and tested by different studies. S. Dimerel, M. Tuzen, S. Saracoglu, and M. Soylak published an article in the *Journal of Hazardous Materials* in 2008 that investigated the reliability of various digestion methods. Dry ashing, wet ashing, and microwave digestion were compared and used to analyze known concentrations of substances. The researchers concluded that the microwave digestion method had a higher recovery in a

shorter amount of time and, therefore, deemed it the best of the three different techniques.[21]

Hydrochloric acid, hydrofluoric acid, nitric acid and hydrogen peroxide are all different chemicals often used to digest materials in flame atomic absorption spectroscopy. A. Bazzi, B. Kreuz, and J. Fischer used 6 M hydrochloric acid to treat cereal samples,[22] while N. Cha, et al. used a 7:3:2 ratio of nitric acid, hydrofluoric acid, and hydrochloric acid, respectively.[23] Nitric acid and hydrogen peroxide was used in 2008 in an analysis of dried fruit[24] and that same method was used in 2010 on a study of dog foods.[1] It is apparent from these studies that at least one strong acid is needed to dissolve samples when using this method of spectroscopy.

In a study by D. Alomar, et al. near infrared reflectance spectroscopy was investigated as an alternative method of determining the nutrient content of dog foods. While this method successfully identified the concentration of crude fiber and gross energy, it was not accurate in determining the amount of trace minerals found in the dog food.[25] S. Simcock, S. Rutherfurd, T. Wester, and W. Hendriks also used an alternative method for analyzing pet foods in New Zealand. These researchers used a fluorometric method to analyze the selenium content in both wet and dry pet foods. Although the range of selenium concentrations in each type of food was very different, this method worked well and produced usable results.[26] However, these methods were limited to measuring only selenium concentrations and not that of other metal compounds.

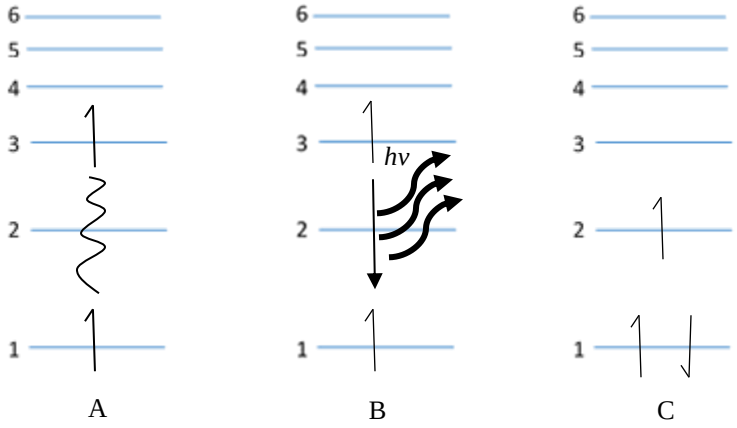

Figure 1: Electron Excitation

To better understand how atomic absorption works, the basics of atomic theory must be discussed. The electrons in atoms exist at all times at certain energy levels, which are denoted generically by the label *n*. As the atoms increase in size, they increase in the number of electrons around the atoms. These atoms fill energy levels with pairs of electrons and as the number of electrons is increased, the distance between the energy levels decreases as shown in Figure 1. To better understand the physical changes that occur in atomic spectroscopy, it is simpler to consider a system in which only one electron exists. Energy absorbed by an electron can promote it from a lower energy level to a higher energy level. This is reflected in Figure 1A as the electron is promoted from n = 1 to n = 3. However, this promotion is not limited to just these two energy levels. For example, an electron could be promoted from n = 2 to n = 3 or n = 1 to n = 5, depending on the amount of energy absorbed by the electron. Having an electron at a higher energy level is energetically unfavorable and, therefore, the electron will eventually fall back down to its original energy level, or its ground state. When the electron returns to its

ground state, it can release energy in the form of a discrete wavelength of light (Figure 1B).[27] While many of these wavelengths are unique for a given element, each element may have multiple wavelengths of light emitted due to its unique combination of electrons around the nucleus and their changing energy levels. For example, lithium has two electrons at n=1 and one electron in its valence shell at n=2 as shown in Figure 1C. These electrons have the opportunity of being promoted to n=3, n=4, n=5, etc. Each transition will provide a different wavelength of light when the electron returns to its ground state.

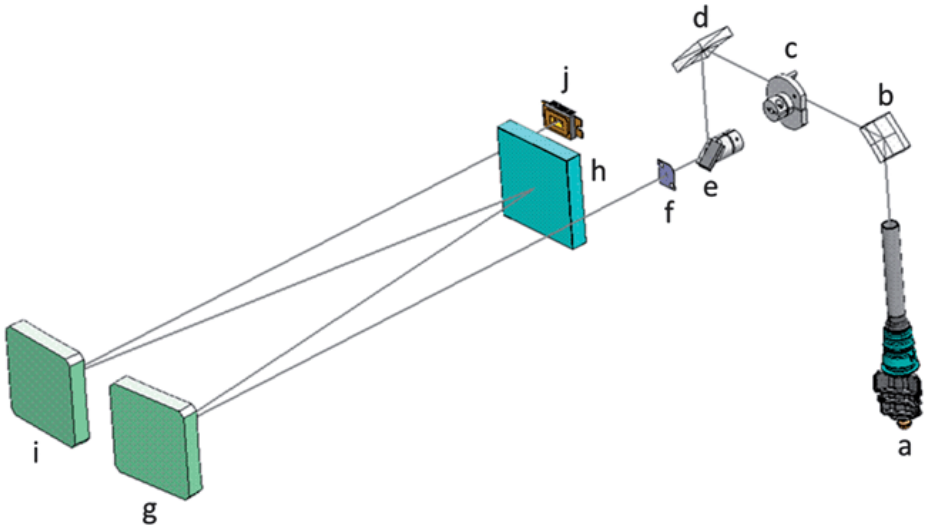

Figure 2: MP-AES Schematic[28]

Atomic emission spectroscopy (AES) relies on the light emitted when an electron returns to its ground state to identify each type of metal. A microwave plasma – atomic emission spectrometer (MP-AES) specifically uses a plasma torch to initially excite electrons as shown in Figure 2 near the point labelled *a*.[28] After excitation, the electrons return to their ground state and emit light that is reflected through the instrument towards a detector which is shown at point *j* in Figure 2. The detector is programmed to detect one wavelength which corresponds to one type of metal at a time. The intensity of the light correlates to the concentration of the metal in the sample. While each wavelength is indicative of a certain element, some elements release light at wavelengths that are close to that of other elements. In these cases, it is important to program the instrument to identify wavelengths that do not interfere with any other elements that are being studied.

Methods

Overview of Approach

Using a modified method from previously described work,[1] several different kinds of dog foods were analyzed for their trace metallic content. Table 2 lists the sources of each of the different dog foods. Before digestion, all dog foods were stored either in their original containers or in plastic bags in a cool, dry area. This storage method was critical as it allowed the food to be free of metal contamination and prevented them from losing very much, if any, of their metal content. Because the MP-AES only analyzes dissolved, aqueous samples, an acid digestion technique involving hydrogen peroxide and nitric acid was used. This digestion technique was also necessary to release the metals from their matrix. Aqueous samples were stored in plastic chemical bottles and diluted to known concentrations. All samples were diluted to a volume of 100 milliliters with the exception of sample 8, which was diluted to 200 milliliters. MP Expert software provided by Agilent was used to operate the instrument as well as collect data from the experiments and quantitatively identify the concentrations of metal compounds in the digested solutions.

Glassware Cleaning Techniques

All glassware used in this investigation was cleaned at the beginning of each semester using an acid solution of aqua regia. ***Extreme caution must be used when preparing and using aqua regia, especially near any organic matter.*** The method for creating aqua regia used in this experiment is thoroughly outlined in a paper published in the *Applied Physics Letters* by S. Han, J. Kim, J. Lee, and Y. Baik.[29] Aqua regia was

produced by carefully combining 6 Molar hydrochloric acid with 69.5 % (15.7 Molar) nitric acid in a 3:1 ratio. The solution was then diluted by 50% using nanopure water. After the aqua regia was generated, glassware that was to be used in the digestion of samples or other parts of the experimental procedure was allowed to soak in the aqua regia solution for thirty seconds to five minutes depending on the relative dirtiness of the glassware. A solution of 50% aqua regia was also used to clean the MP-AES plasma torch periodically when carbon buildup became visible on the outside of the torch. In between acid cleanings, glassware was cleaned by thoroughly rinsing with distilled water and then with nanopure water. If more thorough cleaning was necessary, soap or acetone was used before thorough rinsing with distilled and nanopure water.

Preparation of Dog Food Samples

The dog food was retrieved from storage and 5-20 pieces of kibble were placed in a clean, dry mortar. If the kibble appeared to have a significant amount of water content, they were first dried in a 40°C oven on watch glasses for at least 24 hours. A pestle was used to grind samples to a fine powder after the drying process. Approximately one gram of crushed kibble was weighed into a plastic weigh boat. Twelve milliliters of 69.5% nitric acid was added to four milliliters of 30% hydrogen peroxide in a fifty milliliter beaker. The crushed sample was then added to the digestion solution and placed onto a hot plate. An alundum boiling chip was also placed in the solution to prevent excessive boiling. The temperature was monitored and kept around 100°C. When orange fumes stopped escaping as frequently from the solution, the beakers were removed from heat and allowed to cool. The samples were then filtered and diluted to a known

concentration using a 100 milliliter volumetric flask. A volumetric pipette was used to transfer ten milliliters of each solution to a new volumetric flask to obtain a 1:10 dilution. These solutions were then ready to be analyzed by the instrument. A matrix was digested with each set of samples. A matrix involves using the same procedure outlined for digestion without adding the kibble and is used to identify how much metal is in the digestion mixture.

Preparation of the MP-AES

The instrument used to analyze the samples was an Agilent Technologies 4100 Microwave Plasma- Atomic Emission Spectrometer with a 4200 adaption. MP Expert software was used to obtain data from the instrument. A manual sample introduction was used as well as a linear fit on the calibration curves. The sample uptake time was increased to 80 seconds to account for errors encountered in early trials. In order to obtain results, the correlation coefficient was reduced to 0.9000 and the calibration error was increased to 50%. The wavelengths shown in Table 1 were chosen for each of the metals studied in this experiment. These particular wavelengths were chosen to minimize the amount of interference and error in the data. Standard solutions were prepared by serial dilution from Agilent stock solutions.

Element	Wavelength (nm)
Iron	371.993
Calcium	616.217
Magnesium	766.491
Sodium	518.360
Potassium	588.995

Table 1: Elemental Wavelengths Analyzed from the MP-AES

Sample Number	Brand Name	Source
1	Purina One Smart Blend - Healthy Puppy Formula	Individual
2	Purina Dog Chow	Individual
3	Purina Puppy Chow	Individual
4	Purina Moist and Meaty, Hamburger Flavor	Individual
5	Greenbrier Kennel Club Premium Dog Food	Dollar Tree
6	Iams Sensitive Naturals - Ocean Fish and Rice	Individual
7	Purina Dog Chow*	Individual
8	Orijen Six Fish	Amazon
9	Kibbles 'n Bits Bistro	Amazon
10	Whole Earth Farms Grain Free - Pork, Beef, and Lamb	Amazon
11	Diamond Naturals - Chicken and Sweet Potato	Amazon
12	Iams So Good with Chicken	Amazon
13	Pedigree Small Dog - Chicken	Amazon
14	Eukanuba Excel Adult Formula	Amazon
15	Hills Ideal Balance - Beef, Peas, and Buckwheat	Amazon
16	Newman's Own Adult Recipe	Amazon

Table 2: Dog Food Brands and Sources

* Refers to the blind sample that will be explained vide infra

Results and Analysis

Before the samples were analyzed by the instrument, standard solutions of known concentrations were used to calibrate the MP-AES. The concentrations of the standard solutions are shown below in Table 3. The standard solutions are used to produce calibration curves that the instrument's program can use to determine metal concentrations in unknown samples. It is important to note that parts per million and milligrams per liter are equivalent units and were, therefore, used interchangeably.

Standard Number	Fe (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)
1	5.00	5.00	5.00	5.00	5.00
2	15.00	15.00	15.00	15.00	15.00

Table 3: Standard Solutions for MP-AES Calibration

Table 4 represents values obtained through the MP Expert software without any further manipulation. Although the nanopure water should have had no metal during the analysis, metal concentrations were sporadically found in concentrations of 0.01 milligrams per liter or less. Because these concentrations were miniscule, they should have very little effect, if any, on the results. Table 5 represents the actual concentrations of metals found in the samples after accounting for the matrix values (Sample Calculation 1). These values are more useful for further calculations because they represent the metal concentrations from the dog food alone and excludes the metals that are found in the digestion mixture. Table 5 also contains the mass of each sample digested which was used to further manipulate the data into percent composition for calcium, magnesium, sodium, and potassium (Sample Calculation 2, 3A), while iron was manipulated into milligrams of iron per kilogram of dog food (Sample Calculation 2, 3B). These values

are represented in Table 6. The units for the metal concentrations were chosen to allow for easy comparison to the AAFCO recommended guidelines in Table 7.[25]

	Fe (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)
Nanopure	0.00	0.01	0.00	0.00	0.00
Matrix 1	0.05	0.03	0.01	0.16	0.02
Sample 1	0.08	7.46	0.17	2.07	4.50
Sample 2	0.10	12.81	1.06	4.53	6.83
Sample 3	0.14	18.58	1.19	4.42	7.75
Nanopure	0.01	0.01	0.00	0.00	0.00
Matrix 2	0.02	0.06	0.02	0.13	0.03
Sample 5	0.08	10.78	1.94	3.21	7.57
Sample 6	0.12	8.03	0.90	3.83	7.26
Sample 7	0.08	13.56	1.06	4.53	6.91
NanoPure	0.01	0.00	0.00	0.00	0.00
Matrix 3	0.03	0.14	0.04	0.11	0.05
Sample 8	0.07	8.70	0.80	3.41	5.84
Sample 9	0.14	10.46	1.78	11.04	12.41
Sample 10	0.13	21.01	1.35	4.02	12.26
NanoPure	0.01	0.00	0.00	0.00	0.00
Matrix 4	0.04	0.12	0.04	0.07	0.02
Sample 11	0.13	7.35	1.04	3.93	7.49
Sample 12	0.12	6.13	1.03	2.96	8.38
Sample 13	0.10	10.24	1.04	5.15	7.03
NanoPure	0.01	0.00	0.00	0.00	0.00
Matrix 5	0.04	0.13	0.03	0.14	0.14
Sample 14	0.23	10.82	1.04	4.19	4.19
Sample 16	0.16	10.61	1.20	2.53	2.53

Table 4: Data Obtained From the MP-AES

Sample Calculation 1

$$Metal\ Concentration = Sample - Matrix$$

Sample 1, Iron Concentration

$$Fe\ Concentration = \ 0.08\,{}^{mg}/_{L} - 0.05\,{}^{mg}/_{L} \ = 0.03\,{}^{mg}/_{L}$$

Sample Number	Fe (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Sample (g)
1	0.03	7.43	0.16	1.91	4.48	1.0160
2	0.05	12.78	1.05	4.37	6.81	1.0135
3	0.09	18.55	1.18	4.26	7.73	1.0132
5	0.06	10.72	1.92	3.08	7.54	0.9991
6	0.10	7.97	0.88	3.70	7.23	1.0090
7	0.06	13.50	1.04	4.40	6.88	1.0092
8	0.04	8.56	0.76	3.30	5.79	1.0550
9	0.11	10.32	1.74	10.93	12.36	1.1265
10	0.10	20.87	1.31	3.91	12.21	2.0461
11	0.09	7.23	1.00	3.86	7.47	0.9918
12	0.08	6.01	0.99	2.89	8.36	1.0378
13	0.06	10.12	1.00	5.08	7.01	1.0636
14	0.19	10.69	1.01	4.05	4.05	1.0270
16	0.12	10.48	1.17	2.39	2.39	1.0296

Table 5: Metal Concentrations Without Matrix

Sample Calculation 2

Determining the Metal Composition

$$\frac{milligrams\ of\ metal}{gram\ of\ kibble} = \frac{Metal\ Concentration\ X\ Volume\ of\ Solution}{Mass\ of\ Dog\ Food\ Digested}\ X\ Dilution\ Factor$$

Sample 1, Calcium

$$\frac{milligrams\ of\ metal}{gram\ of\ kibble} = \frac{7.43\ {}^{mg}/_{L}\ X\ 0.1L}{1.0160\ g\ of\ kibble}\ X\ 10 = 7.312\ \frac{mg\ Ca}{g\ kibble}$$

Sample 1, Iron

$$\frac{milligrams\ of\ metal}{gram\ of\ kibble} = \frac{0.03\ {}^{mg}/_{L}\ X\ 0.1L}{1.0160\ g\ of\ kibble}\ X\ 10 = 0.02952\ \frac{mg\ Fe}{g\ kibble}$$

Sample Calculation 3A

Percent Compositions

$$Percent\ Composition = \frac{milligrams\ of\ metal}{gram\ of\ kibble}\ X\ \frac{1\ gram\ of\ kibble}{1000\ milligrams\ of\ kibble}\ X\ 100$$

Sample 1, Calcium

$$Percent\ Composition = \frac{7.312\ mg\ Ca}{g\ kibble}\ X\ \frac{1\ g\ kibble}{1000\ mg\ kibble}\ X\ 100 = 0.7312\ \%\ Ca$$

Sample Calculation 3B

Calculating Iron Concentration

$$Dog\ Food\ Iron\ Composition = \frac{milligrams\ of\ iron}{gram\ of\ kibble}\ X\ \frac{1000\ grams\ of\ kibble}{1\ kilogram\ of\ kibble}$$

Sample 1

$$Iron\ Composition = \frac{0.02952\ mg\ Fe}{1\ g\ kibble}\ X\ \frac{1000\ g\ kibble}{1\ kg\ kibble} = 29.52\ \frac{mg\ Fe}{kg\ kibble}$$

Sample Number	Fe (mg/kg)	Ca (%)	Mg (%)	Na (%)	K (%)
1	29.527559	0.731299	0.015748	0.187992	0.440945
2	49.333991	1.260977	0.103601	0.431179	0.671929
3	88.827477	1.830833	0.116463	0.42045	0.762929
5	60.054049	1.072966	0.192173	0.308277	0.754679
6	99.108028	0.789891	0.087215	0.3667	0.716551
7	59.453032	1.337693	0.103052	0.435989	0.681728
8	75.829384	1.622749	0.122075	0.625592	1.097630
9	97.647581	0.916112	0.154461	0.970262	1.097204
10	48.873467	1.019989	0.064024	0.191095	0.596745
11	90.744102	0.728978	0.100827	0.389191	0.753176
12	77.086144	0.57911	0.095394	0.278474	0.80555
13	56.412185	0.951486	0.09402	0.477623	0.659082
14	185.00487	1.040896	0.098345	0.394352	0.394352
16	116.55012	1.017871	0.113636	0.232129	0.232129

Table 6: Data to be Compared to AAFCO Guidelines

	Fe (mg/kg)	Ca (%)	Mg (%)	Na (%)	K (%)
Minimum	80	0.6	0.04	0.06	0.6
Maximum	3000	2.5	0.3	N/A	N/A

Table 7: AAFCO Values[25]

Figure 3 graphically shows the percent composition of each metal in the dog foods.

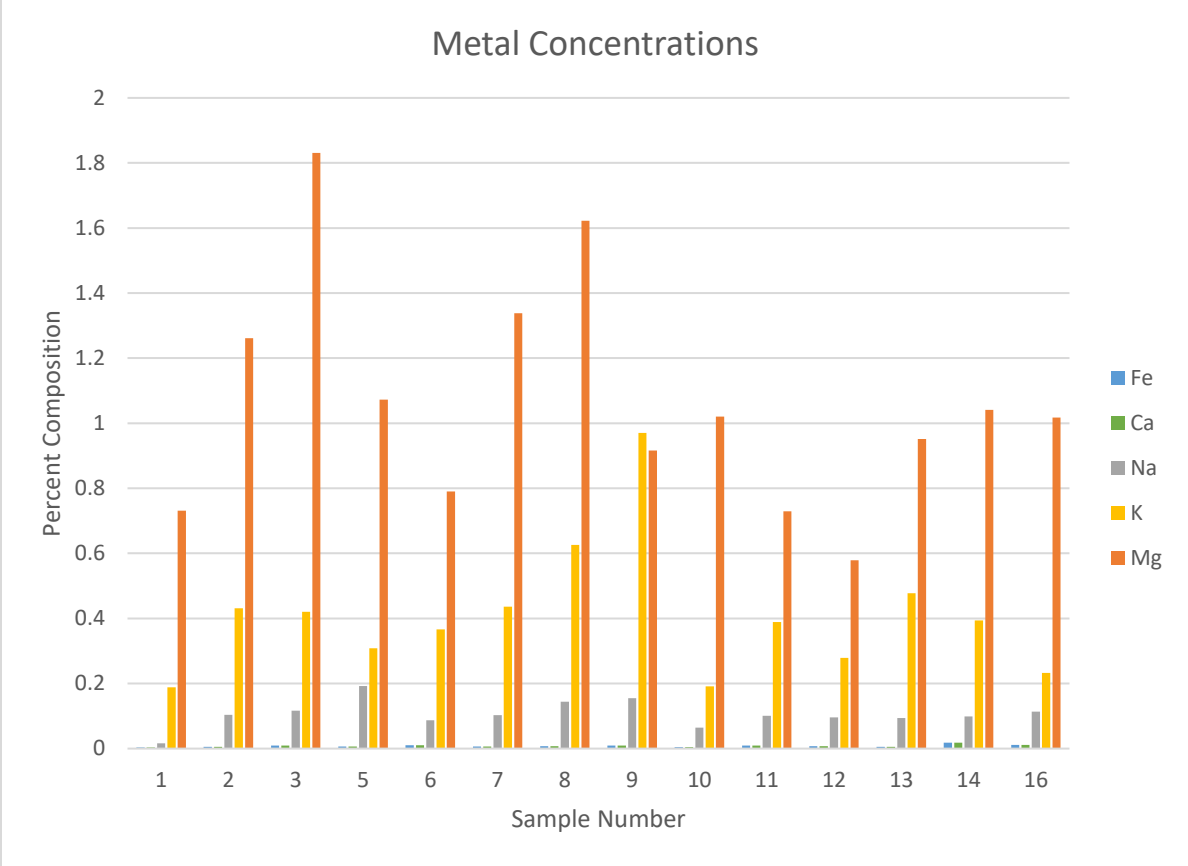

Figure 3: Percent Composition of Metals

The sample values were compared to the AAFCO guidelines through percent difference calculations (Sample Calculation 4) and the results are shown in Table 8. If the values fell between the AAFCO recommended minimum and maximum values, no percent difference was calculated. This comparison is important in determining whether or not an animal is receiving proper nutrition from its food.

Sample Calculation 4

$$Percent\ Difference = \frac{|Theoretical - Experimental|}{\frac{Theoretical + Experimental}{2}}\ X\ 100$$

Sample 1, Iron

$$Percent\ Difference = \frac{|80 - 29.53|}{\frac{80 + 29.53}{2}}\ X\ 100 = 92.16\ \%\ difference$$

Sample Number	Fe	Ca	Mg	Na	K
1	92.16391	0	87.00565	0	30.55976
2	47.42142	0	0	0	0
3	0	0	0	0	0
5	28.48322	0	0	0	0
6	0	0	0	0	0
7	29.46794	0	0	0	0
8	5.352798	0	0	0	0
9	0	0	0	0	0
10	48.30557	0	0	0	0.543971
11	0	0	0	0	0
12	3.709883	3.54341	0	0	0
13	34.58315	0	0	0	0
14	0	0	0	0	41.3631
16	0	0	0	0	88.41683

Table 8: Percent Difference

In order to further evaluate and differentiate the different dog foods, a grading rubric was developed (Table 9). Each metal studied was assigned a weight based on its relative importance in the body as explained in the introduction. The percent difference was used in conjunction with the developed rubric to assign a score (Sample Calculation 5) to each type of dog food for each metal as shown in Table 10. The scores for all of the metals

were added together to create the total score for every sample. A score of 1 was given to dog foods that had metal concentrations that all fell within the AAFCO recommended guidelines. The scores are compared in Figure 4.

	Fe	Ca	Mg	Na	K
Weight	0.25	0.2	0.15	0.25	0.15

Table 9: Weights Developed Based on Importance of Metal

Sample Calculation 5

$$Score = \sum \frac{(100 - Percent\ Difference)}{100} * Weight$$

Sample 1

$$Score = \left[\frac{(100 - 92.16)}{100} * 0.25\right] + \left[\frac{(100 - 0)}{100} * 0.2\right] + \left[\frac{(100 - 87.00)}{100} * 0.15\right]$$

$$+ \left[\frac{(100 - 0)}{100} * 0.25\right] + \left[\frac{(100 - 30.56)}{100} * 0.15\right] = 0.593$$

Sample	Fe	Ca	Mg	Na	K	**Total Score**
1	0.01959	0.2	0.01949	0.25	0.10416	**0.593**
2	0.131446	0.2	0.15	0.25	0.15	**0.881**
3	0.25	0.2	0.15	0.25	0.15	**1.000**
5	0.178792	0.2	0.15	0.25	0.15	**0.929**
6	0.25	0.2	0.15	0.25	0.15	**1.000**
7	0.17633	0.2	0.15	0.25	0.15	**0.926**
8	0.236618	0.2	0.15	0.25	0.15	**0.987**
9	0.25	0.2	0.15	0.25	0.15	**1.000**
10	0.129236	0.2	0.15	0.25	0.149184	**0.878**
11	0.25	0.2	0.15	0.25	0.15	**1.000**
12	0.240725	0.192913	0.15	0.25	0.15	**0.984**
13	0.163542	0.2	0.15	0.25	0.15	**0.914**
14	0.25	0.2	0.15	0.25	0.087955	**0.938**
16	0.25	0.2	0.15	0.25	0.017375	**0.867**

Table 10: Dog Food Scores

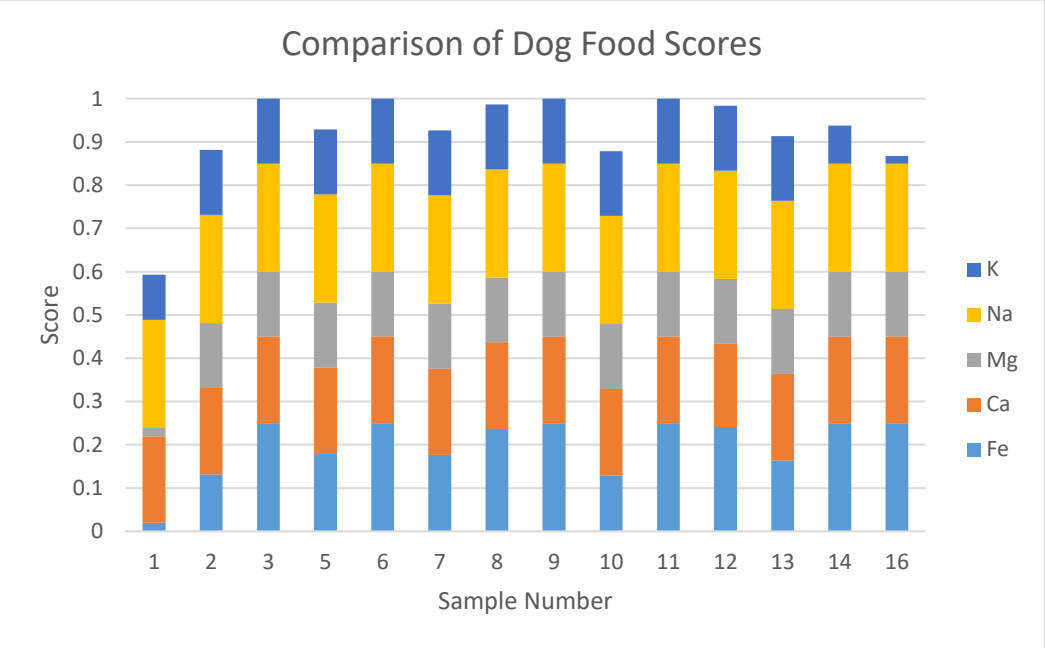

Figure 4: Dog Food Scores

The cost of each type of dog food is represented in Table 11. All prices, except for that of sample 5, were obtained from Amazon. The price of sample 5 was found by its selling price at Dollar Tree. Figure 5 compares the price of the dog food and its score from Table 10 to graphically determine if there is a correlation between price and score.

Sample Number	Price	Weight	Price per Pound
1	11.99	8	1.49875
2	8.75	4.4	1.988636364
3	14.52	4.4	3.3
5	1.00	1.03	0.970873786
6	27.54	17.2	1.601162791
7	8.75	4.4	1.988636364
8	6.24	0.75	8.32
9	5.87	3.5	1.677142857
10	7.99	4	1.9975
11	11.03	5	2.206
12	5.49	3.2	1.715625
13	5.22	3.5	1.491428571
14	4.07	4	1.0175
16	4.39	1.5	2.926666667

Table 11: Prices of Dog Food

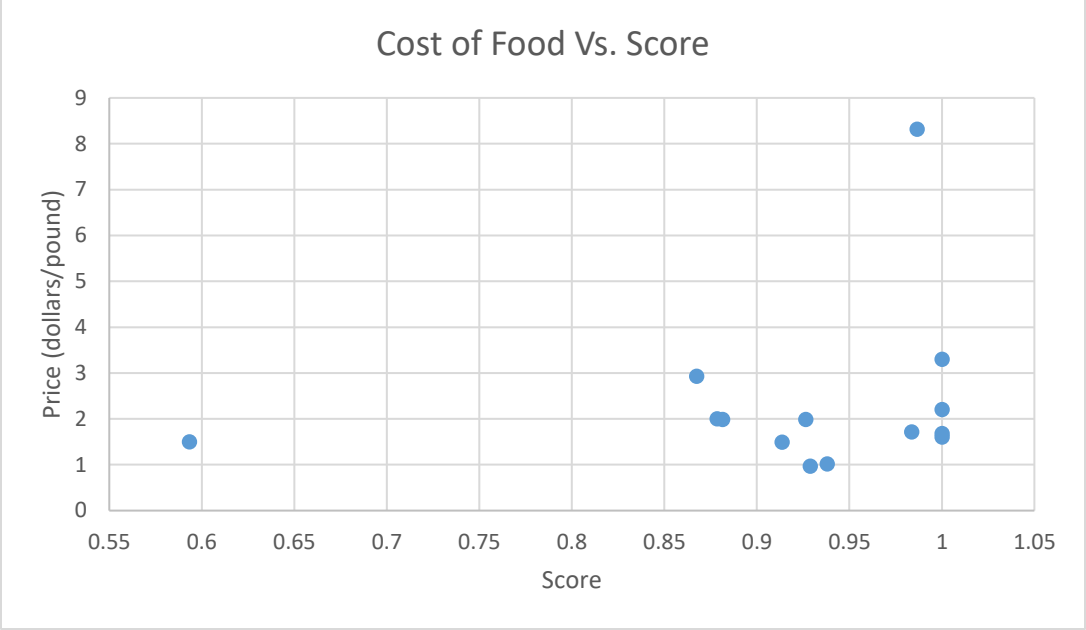

Figure 5: Price Vs. Score

It should be noted that sample 7 was a blind sample throughout this study. At the conclusion, it was revealed that sample 7 was the exact same dog food as sample 2, but they were from two different sources. Although the two did not receive the same score, there was only a 4.98% difference between the two scores (Sample Calculation 6). This difference could be caused by several possible errors including differences in storage, normal variations in dog food companies' products, or slight differences in the digestion procedure.

Sample Calculation 6

$$Percent\ Difference = \frac{|Sample\ 2 - Sample\ 7|}{\frac{Sample\ 2 + Sample\ 7}{2}}\ X\ 100$$

Sample 2 and Sample 7

$$Percent\ Difference = \frac{|0.881 - 0.926|}{\frac{0.881 + 0.926}{2}}\ X\ 100 = 4.98\ \%\ difference$$

Conclusion

Concentrations of iron, calcium, potassium, magnesium, and sodium were quantified using a microwave plasma – atomic emission spectrometer and compared through a self-developed scale. Due to time constraints and unforeseen instrument malfunctions, only one trial was able to be completed. However, a known sample and a blind of the known sample were compared and found to have a low percent difference which indicates that the results are reproducible. From the results represented in Figure 5, there seems to be no direct correlation from the price of a dog food to the score of the kibble. Duplicating this methodology and completing more trials could provide more definitive results. The grading rubric used to score the dog food was developed through research, but could be reassessed in a future study.

Reflection

From the completion of this project, I have learned how to connect the tools and techniques acquired in previous chemistry classes to my interests in veterinary medicine while applying all of these skills to a real world, tangible research project. The process of completing this Honors Project has stretched me both academically and personally as I developed the project, determined instrument malfunctions, overcame unprecedented setbacks, and completed this manuscript. I have increased my ability to decipher primary literature and apply previous research to a new area. While I developed concrete skills such as learning how to operate the microwave plasma – atomic emission spectrometer, I also learned problem solving techniques that will be applicable in my future studies and occupation. If I had the opportunity to complete this project again, more time would be provided to account for inevitable and unforeseen issues.

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Appendices

Appendix A: Grant Proposal

Dear Grant Committee,

Animals are a huge part of the lives of most Americans. If you ask any pet owner, they would tell you that they want to provide the best care for their animals possible. One way to ensure a proper health for pets is to provide a diet that contains the proper nutrients in the proper quantities. Currently, I am conducting primary research analyzing the metal components of different types of gourmet dog foods using atomic absorption spectroscopy via the Chemistry Department's microwave plasma atomic emission spectrometer (MP-AES).

In order to enhance our abilities to successfully analyze these dog food samples, we respectfully request $400 to purchase a plasma torch for the MP-AES. Currently, the Chemistry Department only owns one torch, which is a crucial part of the MP-AES instrumentation. If this torch were to break or be damaged, my research, as well as other research and lab experiments, would no longer be able to be completed. There is a large likelihood that our torch will become damaged by the sheer volume of use that the instrument receives. The instrument would essentially become useless without a working torch and would sit idly until a new torch was procured, which will greatly stymie my research progress. To ensure that my research project will be conducted in a timely and uninterrupted manner, another torch is needed. In addition to seeking funding here, I am also pursing funding of an additional $150 through the Ron and Laura Strain Honors College to help cover the costs of this item.

This project is beneficial to both me and the university in several ways. These funds would allow me to successfully complete my study of the content of dog food. This is of great interest to me because, in the future, I plan to pursue a career in the field of veterinary medicine. Additionally, the completion of this project will bring me one step closer to graduating with distinction through the Ron and Laura Strain Honors College. This project will teach me how to work independently and efficiently. As I move on to professional school, the skills that I am developing through this project, such as efficient use of time and resources, will ensure my success.

In addition, these funds will provide the opportunity for other students to successfully use the MP-AES for projects of their own. This instrument is currently being used in another student-led research project analyzing the heavy metal contamination of soil collected from the Harding Power Plant. This instrument is also used in the instruction of several labs in the chemistry curriculum, including Advanced Lab Techniques and Environmental Chemistry. With so much use, having this extra torch will provide insurance that I will be able to conduct my studies. If you have any further questions regarding my request or research, please feel free to contact me at clintonh@uindy.edu.
Sincerely,

Hannah Clinton

Advisor: Brad Neal

Appendix B: CITI Training

COLLABORATIVE INSTITUTIONAL TRAINING INITIATIVE (CITI)

HUMAN RESEARCH CURRICULUM COMPLETION REPORT

Printed on 10/28/2014

LEARNER

Hannah Clinton (ID: 4307835)

2948 N 225 W

Washington

IN 47501

DEPARTMENT Math

PHONE 812 698 1888

EMAIL clintonh@uindy.edu

INSTITUTION University of Indianapolis

EXPIRATION DATE 08/23/2016

GROUP 2.SOCIAL / BEHAVIORAL RESEARCH INVESTIGATORS AND KEY PERSONNEL. : The social behavioral track is applicable when you conduct epidemiologic, genetic, prevention/ screening, psychosocial and/or quality of life studies.

COURSE/STAGE: Basic Course/1

PASSED ON: 08/24/2014

REFERENCE ID: 13772853

REQUIRED MODULES DATE COMPLETED

Introduction 08/23/14

Students in Research 08/23/14

History and Ethical Principles - SBE 08/23/14

Defining Research with Human Subjects - SBE 08/23/14

The Federal Regulations - SBE 08/23/14

Assessing Risk - SBE 08/23/14

Informed Consent - SBE 08/23/14

Privacy and Confidentiality - SBE 08/24/14

Research and HIPAA Privacy Protections 08/24/14

Conflicts of Interest in Research Involving Human Subjects 08/24/14

For this Completion Report to be valid, the learner listed above must be affiliated with a CITI Program participating institution or be a paid Independent Learner. Falsified information and unauthorized use of the CITI Program course site is unethical, and may be considered research misconduct by your institution.

Paul Braunschweiger Ph.D.

Professor, University of Miami

Director Office of Research Education

CITI Program Course Coordinator

Appendix C: Material Safety Data Sheets

Sigma-Aldrich - 84378 Page 1 of 8
SIGMA-ALDRICH *sigma-aldrich.com*
SAFETY DATA SHEET
Version 5.5
Revision Date 08/23/2014
Print Date 11/03/2014
1. PRODUCT AND COMPANY IDENTIFICATION
1.1 Product identifiers
Product name : Nitric acid
Product Number : 84378
Brand : Sigma-Aldrich
Index-No. : 007-004-00-1
CAS-No. : 7697-37-2
1.2 Relevant identified uses of the substance or mixture and uses advised against
Identified uses : Laboratory chemicals, Manufacture of substances
1.3 Details of the supplier of the safety data sheet
Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA
Telephone : +1 800-325-5832
Fax : +1 800-325-5052
1.4 Emergency telephone number
Emergency Phone # : (314) 776-6555
2. HAZARDS IDENTIFICATION
2.1 Classification of the substance or mixture
GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)
Oxidizing liquids (Category 3), H272
Skin corrosion (Category 1A), H314
Serious eye damage (Category 1), H318
For the full text of the H-Statements mentioned in this Section, see Section 16.
2.2 GHS Label elements, including precautionary statements
Pictogram
Signal word Danger
Hazard statement(s)
H272 May intensify fire; oxidiser.
H314 Causes severe skin burns and eye damage.
Precautionary statement(s)
P210 Keep away from heat.
P220 Keep/Store away from clothing/ combustible materials.
P221 Take any precaution to avoid mixing with combustibles.
P264 Wash skin thoroughly after handling.
P280 Wear protective gloves/ protective clothing/ eye protection/ face protection.
P301 + P330 + P331 IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.
P303 + P361 + P353 IF ON SKIN (or hair): Remove/ Take off immediately all contaminated

clothing. Rinse skin with water/ shower.
P304 + P340 IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
P305 + P351 + P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P310 Immediately call a POISON CENTER or doctor/ physician.
P321 Specific treatment (see supplemental first aid instructions on this label).
P363 Wash contaminated clothing before reuse.
P370 + P378 In case of fire: Use dry sand, dry chemical or alcohol-resistant foam for extinction.
P405 Store locked up.
P501 Dispose of contents/ container to an approved waste disposal plant.
2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none
3. COMPOSITION/INFORMATION ON INGREDIENTS
3.2 Mixtures
Formula : HNO3
Molecular weight : 63.01 g/mol
Component Classification Concentration
Nitric acid
CAS-No.
EC-No.
Index-No.
7697-37-2
231-714-2
007-004-00-1
Ox. Liq. 3; Skin Corr. 1A; Eye
Dam. 1; H272, H314
90 - 100 %
For the full text of the H-Statements mentioned in this Section, see Section 16.
4. FIRST AID MEASURES
4.1 Description of first aid measures
General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.
If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.
In case of skin contact
Take off contaminated clothing and shoes immediately. Wash off with soap and plenty of water. Consult a physician.
In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.Continue rinsing eyes during
transport to hospital.
If swallowed
Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a

physician.

4.2 Most important symptoms and effects, both acute and delayed

The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed

No data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media

Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

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5.2 Special hazards arising from the substance or mixture

Nitrogen oxides (NOx)

5.3 Advice for firefighters

Wear self-contained breathing apparatus for firefighting if necessary.

5.4 Further information

Use water spray to cool unopened containers.

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures

Use personal protective equipment. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate
personnel to safe areas.

For personal protection see section 8.

6.2 Environmental precautions

Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up

Contain spillage, and then collect with an electrically protected vacuum cleaner or by wet-brushing and place in
container for disposal according to local regulations (see section 13).

6.4 Reference to other sections

For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling

Avoid inhalation of vapour or mist.

Keep away from sources of ignition - No smoking.Keep away from heat and sources of ignition.Normal measures for
preventive fire protection.

For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities

Keep container tightly closed in a dry and well-ventilated place. Containers which are opened must be carefully
resealed and kept upright to prevent leakage.

7.3 Specific end use(s)

Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters

Component CAS-No. Value Control

parameters
Basis
Nitric acid 7697-37-2 TWA 2 ppm
USA. ACGIH Threshold Limit Values
(TLV)
Remarks Eye & Upper Respiratory Tract irritation
Dental erosion
STEL 4 ppm
USA. ACGIH Threshold Limit Values
(TLV)
Eye & Upper Respiratory Tract irritation
Dental erosion
ST 4 ppm
10 mg/m3
USA. NIOSH Recommended
Exposure Limits
TWA 2 ppm
5 mg/m3
USA. NIOSH Recommended
Exposure Limits
TWA 2 ppm
5 mg/m3
USA. Occupational Exposure Limits
(OSHA) - Table Z-1 Limits for Air
Contaminants
The value in mg/m3 is approximate.
Sigma-Aldrich - 84378 Page 4 of 8
TWA 2 ppm
5 mg/m3
USA. OSHA - TABLE Z-1 Limits for
Air Contaminants - 1910.1000
STEL 4 ppm
10 mg/m3
USA. OSHA - TABLE Z-1 Limits for
Air Contaminants - 1910.1000

8.2 Exposure controls

Appropriate engineering controls

Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of
workday.

Personal protective equipment

Eye/face protection

Tightly fitting safety goggles. Faceshield (8-inch minimum). Use equipment for eye protection tested and
approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection

Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without

touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after
use in accordance with applicable laws and good laboratory practices. Wash and dry hands.
Full contact
Material: Fluorinated rubber
Minimum layer thickness: 0.7 mm
Break through time: 480 min
Material tested:Vitoject® (KCL 890 / Aldrich Z677698, Size M)
Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 30 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)
data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method:
EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the
supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an
industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It
should not be construed as offering an approval for any specific use scenario.

Body Protection

Complete suit protecting against chemicals, The type of protective equipment must be selected according to
the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection

Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multipurpose
combination (US) or type ABEK (EN 14387) respirator cartridges as a backup to engineering controls.
If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and
components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure

Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a) Appearance Form: liquid
Colour: colourless
b) Odour No data available
c) Odour Threshold No data available
d) pH < 1.0
e) Melting point/freezing
point
No data available

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f) Initial boiling point and
boiling range
120.5 °C (248.9 °F) - lit.
g) Flash point No data available
h) Evaporation rate No data available
i) Flammability (solid, gas) No data available
j) Upper/lower
flammability or
explosive limits
No data available
k) Vapour pressure 49 hPa (37 mmHg) at 50 °C (122 °F)
l) Vapour density No data available
m) Relative density 1.37 - 1.41 g/cm3 at 20 °C (68 °F)
n) Water solubility No data available
o) Partition coefficient: noctanol/
water
No data available
p) Auto-ignition
temperature
No data available
q) Decomposition
temperature
No data available
r) Viscosity No data available
s) Explosive properties No data available
t) Oxidizing properties No data available

9.2 Other safety information

No data available

10. STABILITY AND REACTIVITY

10.1 Reactivity

No data available

10.2 Chemical stability

Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions

No data available

10.4 Conditions to avoid

No data available

10.5 Incompatible materials

Alkali metals, Acetic anhydride, Organic materials, Alcohols, Acetonitrile, Acrylonitrile

10.6 Hazardous decomposition products

Other decomposition products - No data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity

No data available
Inhalation: No data available

Dermal: No data available
No data available
Sigma-Aldrich - 84378 Page 6 of 8
Skin corrosion/irritation
No data available
Serious eye damage/eye irritation
No data available
Respiratory or skin sensitisation
No data available
Germ cell mutagenicity
No data available
Carcinogenicity
IARC: No component of this product present at levels greater than or equal to 0.1% is identified as
probable, possible or confirmed human carcinogen by IARC.
ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a
carcinogen or potential carcinogen by ACGIH.
NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a
known or anticipated carcinogen by NTP.
OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a
carcinogen or potential carcinogen by OSHA.
Reproductive toxicity
No data available
No data available
Specific target organ toxicity - single exposure
No data available
Specific target organ toxicity - repeated exposure
No data available
Aspiration hazard
No data available
Additional Information
RTECS: Not available
Material is extremely destructive to tissue of the mucous membranes and upper respiratory tract, eyes, and skin.,
Inhalation may provoke the following symptoms:, spasm, inflammation and edema of the bronchi, spasm, inflammation
and edema of the larynx, pneumonitis, Symptoms and signs of poisoning are:, burning sensation, Cough, wheezing,
laryngitis, Shortness of breath, Headache, Nausea, Vomiting, Pulmonary edema. Effects may be delayed., Large doses
may cause: conversion of hemoglobin to methemoglobin, producing cyanosis; marked fall in blood pressure, leading to
collapse, coma, and possibly death.
Liver - Irregularities - Based on Human Evidence
Liver - Irregularities - Based on Human Evidence

12. ECOLOGICAL INFORMATION
12.1 Toxicity
No data available
12.2 Persistence and degradability
No data available
12.3 Bioaccumulative potential
No data available
12.4 Mobility in soil
No data available
12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted
Sigma-Aldrich - 84378 Page 7 of 8
12.6 Other adverse effects
No data available
13. DISPOSAL CONSIDERATIONS
13.1 Waste treatment methods
Product
Burn in a chemical incinerator equipped with an afterburner and scrubber but exert extra care in igniting as this
material is highly flammable. Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a
licensed professional waste disposal service to dispose of this material. Dissolve or mix the material with a
combustible solvent and burn in a chemical incinerator equipped with an afterburner and scrubber.
Contaminated packaging
Dispose of as unused product.
14. TRANSPORT INFORMATION
DOT (US)
UN number: 2031 Class: 8 (5.1) Packing group: II
Proper shipping name: Nitric acid
Reportable Quantity (RQ): 1000 lbs
Marine pollutant: No
Poison Inhalation Hazard: No
IMDG
UN number: 2031 Class: 8 (5.1) Packing group: II EMS-No: F-A, S-Q
Proper shipping name: NITRIC ACID
Marine pollutant: No
IATA
UN number: 2031 Class: 8 (5.1) Packing group: II
Proper shipping name: Nitric acid
IATA Passenger: Not permitted for transport
15. REGULATORY INFORMATION
SARA 302 Components
Nitric acid
CAS-No.
7697-37-2
Revision Date

2007-07-01
SARA 313 Components
Nitric acid
CAS-No.
7697-37-2
Revision Date
2007-07-01
SARA 311/312 Hazards
Acute Health Hazard, Chronic Health Hazard
Massachusetts Right To Know Components
Nitric acid
CAS-No.
7697-37-2
Revision Date
2007-07-01
Pennsylvania Right To Know Components
Water
CAS-No.
7732-18-5
Revision Date
Nitric acid 7697-37-2 2007-07-01
New Jersey Right To Know Components
Water
CAS-No.
7732-18-5
Revision Date
Nitric acid 7697-37-2 2007-07-01
California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other
reproductive harm.
Sigma-Aldrich - 84378 Page 8 of 8
16. OTHER INFORMATION
Full text of H-Statements referred to under sections 2 and 3.
Eye Dam. Serious eye damage
H272 May intensify fire; oxidiser.
H314 Causes severe skin burns and eye damage.
H318 Causes serious eye damage.
Ox. Liq. Oxidizing liquids
Skin Corr. Skin corrosion
HMIS Rating
Health hazard: 3
Chronic Health Hazard: *
Flammability: 0
Physical Hazard 3
NFPA Rating
Health hazard: 3
Fire Hazard: 0

Reactivity Hazard: 0

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information

Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956
Version: 5.5 Revision Date: 08/23/2014 Print Date: 11/03/2014

SIGMA-ALDRICH ***sigma-aldrich.com***
SAFETY DATA SHEET
Version 5.5
Revision Date 03/07/2014
Print Date 04/02/2016

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Hydrochloric acid
Product Number : 339253
Brand : Sigma-Aldrich
Index-No. : 017-002-01-X
REACH No. : 01-2119484862-27-XXXX
CAS-No. : 7647-01-0

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA
Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)
Corrosive to metals (Category 1), H290
Skin corrosion (Category 1B), H314
Serious eye damage (Category 1), H318
Specific target organ toxicity - single exposure (Category 3), Respiratory system, H335
For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram
Signal word Danger
Hazard statement(s)
H290 May be corrosive to metals.
H314 Causes severe skin burns and eye damage.
H335 May cause respiratory irritation.
Precautionary statement(s)
P234 Keep only in original container.
P261 Avoid breathing dust/ fume/ gas/ mist/ vapours/ spray.
P264 Wash skin thoroughly after handling.
P271 Use only outdoors or in a well-ventilated area.
P280 Wear protective gloves/ protective clothing/ eye protection/ face protection.

P301 + P330 + P331 IF SWALLOWED: rinse mouth. Do NOT induce vomiting.
P303 + P361 + P353 IF ON SKIN (or hair): Remove/ Take off immediately all contaminated clothing. Rinse skin with water/ shower.
P304 + P340 IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
P305 + P351 + P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P310 Immediately call a POISON CENTER or doctor/ physician.
P321 Specific treatment (see supplemental first aid instructions on this label).
P363 Wash contaminated clothing before reuse.
P390 Absorb spillage to prevent material damage.
P403 + P233 Store in a well-ventilated place. Keep container tightly closed.
P405 Store locked up.
P406 Store in corrosive resistant stainless steel container with a resistant inner liner.
P501 Dispose of contents/ container to an approved waste disposal plant.
2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none
3. COMPOSITION/INFORMATION ON INGREDIENTS
3.2 Mixtures
Formula : HCl
Molecular Weight : 36.46 g/mol
Hazardous components
Component Classification Concentration
Hydrochloric acid
CAS-No.
EC-No.
Index-No.
Registration number
7647-01-0
231-595-7
017-002-01-X
01-2119484862-27-XXXX
Met. Corr. 1; Skin Corr. 1B;
Eye Dam. 1; STOT SE 3;
H290, H314, H335
30 - 50 %
For the full text of the H-Statements mentioned in this Section, see Section 16.
4. FIRST AID MEASURES
4.1 Description of first aid measures
General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.
If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.
In case of skin contact
Take off contaminated clothing and shoes immediately. Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.Continue rinsing eyes during
transport to hospital.
If swallowed
Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a
physician.
4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11
4.3 Indication of any immediate medical attention and special treatment needed
no data available
Sigma-Aldrich - 339253 Page 3 of 8
5. FIREFIGHTING MEASURES
5.1 Extinguishing media
Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.
5.2 Special hazards arising from the substance or mixture
Hydrogen chloride gas
Hydrogen chloride gas
5.3 Advice for firefighters
Wear self contained breathing apparatus for fire fighting if necessary.
5.4 Further information
no data available
6. ACCIDENTAL RELEASE MEASURES
6.1 Personal precautions, protective equipment and emergency procedures
Wear respiratory protection. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate personnel
to safe areas.
For personal protection see section 8.
6.2 Environmental precautions
Do not let product enter drains.
6.3 Methods and materials for containment and cleaning up
Soak up with inert absorbent material and dispose of as hazardous waste. Keep in suitable, closed containers for
disposal.
6.4 Reference to other sections
For disposal see section 13.
7. HANDLING AND STORAGE
7.1 Precautions for safe handling
Avoid contact with skin and eyes. Avoid inhalation of vapour or mist.
For precautions see section 2.2.
7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place. Containers which are opened must be carefully
resealed and kept upright to prevent leakage.
7.3 Specific end use(s)

Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters

Component CAS-No. Value Control
parameters
Basis
Hydrochloric acid 7647-01-0 C 2 ppm
USA. ACGIH Threshold Limit Values
(TLV)
Remarks Upper Respiratory Tract irritation
Not classifiable as a human carcinogen
C 5 ppm
7 mg/m3
USA. Occupational Exposure Limits
(OSHA) - Table Z-1 Limits for Air
Contaminants
The value in mg/m3 is approximate.
Ceiling limit is to be determined from breathing-zone air samples.
Sigma-Aldrich - 339253 Page 4 of 8
C 5 ppm
7 mg/m3
USA. OSHA - TABLE Z-1 Limits for
Air Contaminants - 1910.1000
C 5 ppm
7 mg/m3
USA. NIOSH Recommended
Exposure Limits
Often used in an aqueous solution.

8.2 Exposure controls

Appropriate engineering controls

Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of
workday.

Personal protective equipment

Eye/face protection

Tightly fitting safety goggles. Faceshield (8-inch minimum). Use equipment for eye protection tested and
approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection

Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without
touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after
use in accordance with applicable laws and good laboratory practices. Wash and dry hands.
Full contact
Material: Nitrile rubber
Minimum layer thickness: 0.4 mm

Break through time: 480 min
Material tested:Camatril® (KCL 730 / Aldrich Z677442, Size M)
Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 120 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)
data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method:
EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the
supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an
industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It
should not be construed as offering an approval for any specific use scenario.

Body Protection

Complete suit protecting against chemicals, The type of protective equipment must be selected according to
the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection

Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multipurpose
combination (US) or type ABEK (EN 14387) respirator cartridges as a backup to engineering controls.
If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and
components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure

Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a) Appearance Form: liquid
Colour: light yellow
b) Odour pungent
c) Odour Threshold no data available
d) pH no data available
e) Melting point/freezing point -30 °C (-22 °F)

f) Initial boiling point and boiling range
> 100 °C (> 212 °F) - lit.
g) Flash point not applicable
h) Evapouration rate no data available
i) Flammability (solid, gas) no data available

j) Upper/lower
flammability or
explosive limits
no data available
k) Vapour pressure 227 hPa (170 mmHg) at 21.1 °C (70.0 °F)
547 hPa (410 mmHg) at 37.7 °C (99.9 °F)
l) Vapour density no data available
m) Relative density 1.2 g/cm3 at 25 °C (77 °F)
n) Water solubility soluble
o) Partition coefficient: noctanol/
water
no data available
p) Auto-ignition
temperature
no data available
q) Decomposition
temperature
no data available
r) Viscosity no data available
s) Explosive properties no data available
t) Oxidizing properties no data available

9.2 Other safety information

no data available

10. STABILITY AND REACTIVITY

10.1 Reactivity

no data available

10.2 Chemical stability

Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions

no data available

10.4 Conditions to avoid

no data available

10.5 Incompatible materials

Bases, Amines, Alkali metals, Metals, permanganates, e.g. potassium permanganate, Fluorine, metal acetylides,
hexalithium disilicide

10.6 Hazardous decomposition products

Other decomposition products - no data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity

no data available (Hydrochloric acid)
Inhalation: no data available (Hydrochloric acid)
Sigma-Aldrich - 339253 Page 6 of 8
Dermal: no data available (Hydrochloric acid)
no data available (Hydrochloric acid)

Skin corrosion/irritation

Skin - rabbit
Result: Causes burns.
Serious eye damage/eye irritation
Eyes - rabbit (Hydrochloric acid)
Result: Corrosive to eyes
Respiratory or skin sensitisation
no data available (Hydrochloric acid)
Germ cell mutagenicity
no data available (Hydrochloric acid)
Carcinogenicity
This product is or contains a component that is not classifiable as to its carcinogenicity based on its IARC, ACGIH,
NTP, or EPA classification. (Hydrochloric acid)
(Hydrochloric acid)
(Hydrochloric acid)
IARC: 3 - Group 3: Not classifiable as to its carcinogenicity to humans (Hydrochloric acid)
NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a
known or anticipated carcinogen by NTP.
OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a
carcinogen or potential carcinogen by OSHA.
Reproductive toxicity
no data available (Hydrochloric acid)
no data available (Hydrochloric acid)
Specific target organ toxicity - single exposure
The substance or mixture is classified as specific target organ toxicant, single exposure, category 3 with respiratory
tract irritation. (Hydrochloric acid)
Specific target organ toxicity - repeated exposure
no data available
Aspiration hazard
no data available (Hydrochloric acid)
Additional Information
RTECS: MW4025000
burning sensation, Cough, wheezing, laryngitis, Shortness of breath, spasm, inflammation and edema of the larynx,
spasm, inflammation and edema of the bronchi, pneumonitis, pulmonary edema, Material is extremely destructive to
tissue of the mucous membranes and upper respiratory tract, eyes, and skin. (Hydrochloric acid)
12. ECOLOGICAL INFORMATION
12.1 Toxicity
Toxicity to fish LC50 - Gambusia affinis (Mosquito fish) - 282 mg/l - 96 h (Hydrochloric acid)
12.2 Persistence and degradability
no data available
12.3 Bioaccumulative potential
no data available
12.4 Mobility in soil

no data available (Hydrochloric acid)
Sigma-Aldrich - 339253 Page 7 of 8
12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted
12.6 Other adverse effects
no data available
13. DISPOSAL CONSIDERATIONS
13.1 Waste treatment methods
Product
Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste
disposal service to dispose of this material. Dissolve or mix the material with a combustible solvent and burn in a
chemical incinerator equipped with an afterburner and scrubber.
Contaminated packaging
Dispose of as unused product.
14. TRANSPORT INFORMATION
DOT (US)
UN number: 1789 Class: 8 Packing group: II
Proper shipping name: Hydrochloric acid
Reportable Quantity (RQ): 13514 lbs
Marine pollutant: No
Poison Inhalation Hazard: No
IMDG
UN number: 1789 Class: 8 Packing group: II EMS-No: F-A, S-B
Proper shipping name: HYDROCHLORIC ACID
Marine pollutant: No
IATA
UN number: 1789 Class: 8 Packing group: II
Proper shipping name: Hydrochloric acid
15. REGULATORY INFORMATION
REACH No. : 01-2119484862-27-XXXX
SARA 302 Components
SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.
SARA 313 Components
The following components are subject to reporting levels established by SARA Title III, Section 313:
Hydrochloric acid
CAS-No.
7647-01-0
Revision Date
1993-04-24
SARA 311/312 Hazards
Acute Health Hazard
Massachusetts Right To Know Components
Hydrochloric acid
CAS-No.

7647-01-0
Revision Date
1993-04-24
Pennsylvania Right To Know Components
Water
CAS-No.
7732-18-5
Revision Date
Hydrochloric acid 7647-01-0 1993-04-24
New Jersey Right To Know Components
Water
CAS-No.
7732-18-5
Revision Date
Hydrochloric acid 7647-01-0 1993-04-24
California Prop. 65 Components
Sigma-Aldrich - 339253 Page 8 of 8
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other
reproductive harm.
16. OTHER INFORMATION
Full text of H-Statements referred to under sections 2 and 3.
Eye Dam. Serious eye damage
H290 May be corrosive to metals.
H314 Causes severe skin burns and eye damage.
H318 Causes serious eye damage.
H335 May cause respiratory irritation.
Met. Corr. Corrosive to metals
Skin Corr. Skin corrosion
STOT SE Specific target organ toxicity - single exposure
HMIS Rating
Health hazard: 3
Chronic Health Hazard:
Flammability: 0
Physical Hazard 0
NFPA Rating
Health hazard: 3
Fire Hazard: 0
Reactivity Hazard: 0
Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a
guide. The information in this document is based on the present state of our knowledge and is applicable to the
product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the

product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling
or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing
slip for additional terms and conditions of sale.

Preparation Information

Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956
Version: 5.5 Revision Date: 03/07/2014 Print Date: 04/02/2016

SIGMA-ALDRICH ***sigma-aldrich.com***
SAFETY DATA SHEET
Version 3.13
Revision Date 10/07/2015
Print Date 04/02/2016

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name : Hydrogen peroxide solution
Product Number : H1009
Brand : Sigma
CAS-No. : 7722-84-1

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Synthesis of substances

1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA
Telephone : +1 800-325-5832
Fax : +1 800-325-5052

1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)
Oxidizing liquids (Category 1), H271
Acute toxicity, Oral (Category 4), H302
Skin corrosion (Category 1A), H314
Serious eye damage (Category 1), H318
Acute aquatic toxicity (Category 3), H402
For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram
Signal word Danger
Hazard statement(s)
H271 May cause fire or explosion; strong oxidizer.
H302 Harmful if swallowed.
H314 Causes severe skin burns and eye damage.
H318 Causes serious eye damage.
H402 Harmful to aquatic life.
Precautionary statement(s)
P210 Keep away from heat.
P220 Keep/Store away from clothing/ combustible materials.
P221 Take any precaution to avoid mixing with combustibles.

P264 Wash skin thoroughly after handling.
P270 Do not eat, drink or smoke when using this product.

P273 Avoid release to the environment.
P280 Wear protective gloves/ protective clothing/ eye protection/ face protection.
P283 Wear fire/ flame resistant/ retardant clothing.
P301 + P312 + P330 IF SWALLOWED: Call a POISON CENTER or doctor/ physician if you feel unwell. Rinse mouth.
P301 + P330 + P331 IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.
P303 + P361 + P353 IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower.
P304 + P340 + P310 IF INHALED: Remove person to fresh air and keep comfortable for breathing. Immediately call a POISON CENTER or doctor/ physician.
P305 + P351 + P338 + P310 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a POISON CENTER or doctor/ physician.
P306 + P360 IF ON CLOTHING: rinse immediately contaminated clothing and skin with plenty of water before removing clothes.
P363 Wash contaminated clothing before reuse.
P370 + P378 In case of fire: Use dry sand, dry chemical or alcohol-resistant foam to extinguish.
P371 + P380 + P375 In case of major fire and large quantities: Evacuate area. Fight fire remotely due to the risk of explosion.
P405 Store locked up.
P501 Dispose of contents/ container to an approved waste disposal plant.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.2 Mixtures

Formula : H_2O_2
Molecular weight : 34.01 g/mol

Hazardous components

Component	Classification	Concentration
Hydrogen peroxide		
CAS-No. EC-No. Index-No.	7722-84-1 231-765-0 008-003-00-9	
	Ox. Liq. 1; Acute Tox. 4; Skin Corr. 1A; Eye Dam. 1; Aquatic Acute 3; H271, H302 + H332, H314, H318, H402	>= 30 - < 50 %

For the full text of the H-Statements mentioned in this Section, see Section 16.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice

Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled

If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact

Take off contaminated clothing and shoes immediately. Wash off with soap and plenty of water. Consult a physician.

In case of eye contact

Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.Continue rinsing eyes during
transport to hospital.

If swallowed

Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a
physician.

4.2 Most important symptoms and effects, both acute and delayed

The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed

No data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media

Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture

Nature of decomposition products not known.

5.3 Advice for firefighters

Wear self-contained breathing apparatus for firefighting if necessary.

5.4 Further information

Use water spray to cool unopened containers.

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures

Use personal protective equipment. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate
personnel to safe areas.
For personal protection see section 8.

6.2 Environmental precautions

Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment
must be avoided.

6.3 Methods and materials for containment and cleaning up

Contain spillage, and then collect with an electrically protected vacuum cleaner or by wet-brushing and place in
container for disposal according to local regulations (see section 13).

6.4 Reference to other sections

For disposal see section 13.

7. HANDLING AND STORAGE
7.1 Precautions for safe handling
Avoid contact with skin and eyes. Avoid inhalation of vapour or mist.
Keep away from sources of ignition - No smoking.
For precautions see section 2.2.
7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place. Containers which are opened must be carefully
resealed and kept upright to prevent leakage.
Recommended storage temperature 2 - 8 °C
7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated
8. EXPOSURE CONTROLS/PERSONAL PROTECTION
8.1 Control parameters
Components with workplace control parameters
Component CAS-No. Value Control
parameters
Basis
Hydrogen peroxide 7722-84-1 TWA 1.000000 ppm
USA. ACGIH Threshold Limit Values
(TLV)
Remarks Upper Respiratory Tract irritation
Eye irritation
Skin irritation
Sigma - H1009 Page 4 of 8
Confirmed animal carcinogen with unknown relevance to humans
TWA 1.000000 ppm
1.400000
mg/m3
USA. NIOSH Recommended
Exposure Limits
TWA 1.000000 ppm
1.400000
mg/m3
USA. Occupational Exposure Limits
(OSHA) - Table Z-1 Limits for Air
Contaminants
The value in mg/m3 is approximate.
TWA 1 ppm
USA. ACGIH Threshold Limit Values
(TLV)
Upper Respiratory Tract irritation
Eye irritation
Skin irritation
Confirmed animal carcinogen with unknown relevance to humans
TWA 1 ppm
1.4 mg/m3
USA. NIOSH Recommended

Exposure Limits
TWA 1 ppm
1.4 mg/m3
USA. Occupational Exposure Limits
(OSHA) - Table Z-1 Limits for Air
Contaminants
The value in mg/m3 is approximate.
TWA 1 ppm
1.4 mg/m3
USA. OSHA - TABLE Z-1 Limits for
Air Contaminants - 1910.1000

8.2 Exposure controls

Appropriate engineering controls

Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of
workday.

Personal protective equipment

Eye/face protection

Tightly fitting safety goggles. Faceshield (8-inch minimum). Use equipment for eye protection tested and
approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection

Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without
touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after
use in accordance with applicable laws and good laboratory practices. Wash and dry hands.
Full contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)
Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)
data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method:
EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the
supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an
industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It
should not be construed as offering an approval for any specific use scenario.

Body Protection

Complete suit protecting against chemicals, The type of protective equipment must be selected according to
the concentration and amount of the dangerous substance at the specific workplace.
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Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multipurpose
combination (US) or type ABEK (EN 14387) respirator cartridges as a backup to engineering controls.
If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and
components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).
Control of environmental exposure
Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the
environment must be avoided.
9. PHYSICAL AND CHEMICAL PROPERTIES
9.1 Information on basic physical and chemical properties
a) Appearance Form: clear, liquid
Colour: colourless
b) Odour No data available
c) Odour Threshold No data available
d) pH No data available
e) Melting point/freezing
point
No data available
f) Initial boiling point and
boiling range
No data available
g) Flash point No data available
h) Evaporation rate No data available
i) Flammability (solid, gas) No data available
j) Upper/lower
flammability or
explosive limits
No data available
k) Vapour pressure No data available
l) Vapour density No data available
m) Relative density 1.110 g/cm3
n) Water solubility No data available
o) Partition coefficient: noctanol/
water
No data available
p) Auto-ignition
temperature
No data available
q) Decomposition

temperature
No data available
r) Viscosity No data available
s) Explosive properties No data available
t) Oxidizing properties No data available
9.2 Other safety information
No data available
10. STABILITY AND REACTIVITY
10.1 Reactivity
No data available
10.2 Chemical stability
Stable under recommended storage conditions.
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10.3 Possibility of hazardous reactions
No data available
10.4 Conditions to avoid
No data available
10.5 Incompatible materials
Zinc, Powdered metals, Iron, Copper, Nickel, Brass, Iron and iron salts.
10.6 Hazardous decomposition products
In the event of fire: see section 5
11. TOXICOLOGICAL INFORMATION
11.1 Information on toxicological effects
Acute toxicity
LD50 Oral - Acute toxicity estimate - 1,253 mg/kg
(Calculation method)
Inhalation: No data available
Dermal: No data available
No data available
Skin corrosion/irritation
No data available
Serious eye damage/eye irritation
No data available
Respiratory or skin sensitisation
No data available
Germ cell mutagenicity
No data available
Carcinogenicity
IARC: 3 - Group 3: Not classifiable as to its carcinogenicity to humans (Hydrogen peroxide)
NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a
known or anticipated carcinogen by NTP.
OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a
carcinogen or potential carcinogen by OSHA.
Reproductive toxicity
No data available
No data available

Specific target organ toxicity - single exposure
No data available
Specific target organ toxicity - repeated exposure
No data available
Aspiration hazard
No data available
Additional Information
RTECS: Not available
To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly
investigated.
Stomach - Irregularities - Based on Human Evidence
Stomach - Irregularities - Based on Human Evidence (Hydrogen peroxide)
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12. ECOLOGICAL INFORMATION
12.1 Toxicity
No data available
12.2 Persistence and degradability
No data available
12.3 Bioaccumulative potential
No data available
12.4 Mobility in soil
No data available
12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted
12.6 Other adverse effects
An environmental hazard cannot be excluded in the event of unprofessional handling or disposal.
Harmful to aquatic life.
13. DISPOSAL CONSIDERATIONS
13.1 Waste treatment methods
Product
Burn in a chemical incinerator equipped with an afterburner and scrubber but exert extra care in igniting as this
material is highly flammable. Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a
licensed professional waste disposal service to dispose of this material. Dissolve or mix the material with a
combustible solvent and burn in a chemical incinerator equipped with an afterburner and scrubber.
Contaminated packaging
Dispose of as unused product.
14. TRANSPORT INFORMATION
DOT (US)
UN number: 2014 Class: 5.1 (8) Packing group: II
Proper shipping name: Hydrogen peroxide, aqueous solutions
Reportable Quantity (RQ):
Poison Inhalation Hazard: No
IMDG

UN number: 2014 Class: 5.1 (8) Packing group: II EMS-No: F-H, S-Q
Proper shipping name: HYDROGEN PEROXIDE, AQUEOUS SOLUTION
IATA
UN number: 2014 Class: 5.1 (8) Packing group: II
Proper shipping name: Hydrogen peroxide, aqueous solution
15. REGULATORY INFORMATION
SARA 302 Components
The following components are subject to reporting levels established by SARA Title III, Section 302:
Hydrogen peroxide
CAS-No.
7722-84-1
Revision Date
1993-04-24
SARA 313 Components
This material does not contain any chemical components with known CAS numbers that exceed the threshold (De
Minimis) reporting levels established by SARA Title III, Section 313.
SARA 311/312 Hazards
Reactivity Hazard, Acute Health Hazard, Chronic Health Hazard
Massachusetts Right To Know Components
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Hydrogen peroxide
CAS-No.
7722-84-1
Revision Date
1993-04-24
Pennsylvania Right To Know Components
Water
CAS-No.
7732-18-5
Revision Date
Hydrogen peroxide 7722-84-1 1993-04-24
New Jersey Right To Know Components
Water
CAS-No.
7732-18-5
Revision Date
Hydrogen peroxide 7722-84-1 1993-04-24
California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other
reproductive harm.
16. OTHER INFORMATION
Full text of H-Statements referred to under sections 2 and 3.
Acute Tox. Acute toxicity
Aquatic Acute Acute aquatic toxicity
Eye Dam. Serious eye damage

H271 May cause fire or explosion; strong oxidizer.
H302 Harmful if swallowed.
H302 + H332 Harmful if swallowed or if inhaled
H314 Causes severe skin burns and eye damage.
H318 Causes serious eye damage.
H402 Harmful to aquatic life.
Ox. Liq. Oxidizing liquids
Skin Corr. Skin corrosion

HMIS Rating

Health hazard: 3
Chronic Health Hazard: *
Flammability: 0
Physical Hazard 2

NFPA Rating

Health hazard: 3
Fire Hazard: 0
Reactivity Hazard: 2
Special hazard.I: OX

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a
guide. The information in this document is based on the present state of our knowledge and is applicable to the
product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the
product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling
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Preparation Information

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Product Safety – Americas Region
1-800-521-8956
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