is of leather. It hardens and cracks after being wet, and is too dependent upon being well fitted to the face when made.

(The lecturer exhibited various types of gas shells, helmets, masks, and respirators.)

The following compounds have been used by the Germans in gas clouds or in shells:

- 1—Allyl-iso-thiocyanate (allyl mustard oil), C_3H_5NCS (shell).
- 2—Benzyl bromide, $C_6H_5CH_2Br$ (shell).
- 3—Bromo-acetone, $CH_3Br.CO.CH_3$ (hand grenades).
- 4—Bromated methyl-ethyl-ketone (bromo-ketone), $CH_3Br.CO.C_2H_5$ or $CH_3.CO.CHBr.CH_3$ (shell). Dibromo-ketone, $CH_3.CO.CHBr.CH_2Br$ (shell).
- 5—Bromine, Br_2 (hand grenades).
- 6—Chloro-acetone, $CH_3Cl.CO.CH_3$ (hand grenades).
- 7—Chlorine, Cl_2 (cloud).
- 8—Chloromethyl-chloroformate (palite), $ClCOOCH_2Cl$ (shell).
- 9—Nitro-trichloro-methane (chloropicrin or nitrochloroform), CCl_3NO_2 (shell).
- 10—Chlorosulfonic acid, $SO_3.H.Cl$ (hand grenades and "smoke pots").
- 11—Dichloro-diethylsulfide (mustard gas), $(CH_3ClCH_2)_2S$ (shell).
- 12—Dimethyl sulfate, $(CH_3)_2SO_4$ (hand grenades).
- 13—Diphenyl-chloro-arsine, $(C_6H_5)_2AsCl$ (shell).
- 14—Dichloromethyl ether, $(CH_3Cl)_2O$ (shell).
- 15—Methyl-chlorosulfonate, CH_3ClSO_3 (hand grenades).
- 16—Phenyl-carbylamine chloride, $C_6H_5NCCl_2$ (shell).
- 17—Phosgene (carbonyl chloride), $COCl_2$ (cloud and shell).
- 18—Sulfur trioxide, SO_3 (hand grenades and shell).
- 19—Trichloromethyl-chloroformate (diphosgene, superpalite), $ClCOOCCl_3$ (shell).
- 20—Xylyl bromide (tolyl bromide), $CH_3C_6H_4CH_2Br$ (shell).

THE CONSUMPTION AND COST OF ECONOMIC POISONS IN CALIFORNIA IN 1916¹

By GEORGE P. GRAY

Intimately associated with the production and storage of both animal and vegetable foods is the problem of the control of insects, plant diseases, and rodents, the importance of which is scarcely realized except by those directly concerned. A recent proclamation of the President, however, has given the matter definite recognition by placing the distribution of arsenical insecticides under authority of the Food Administrator. The quantity and kinds of chemicals used in this way as well as in the control of flies, mosquitoes, etc., in the interest of the public health, is of especial interest at the present time to an audience of chemists.

In view of the prevailing high prices of all economic poisons² and the acute shortage of others, it seemed of the highest importance to know as fully as possible the normal consumption in California and to make an estimate of probable increased demands in the future. Steps were therefore taken to collect statistics on consumption, and to ascertain, if possible, whether or not serious shortage of important materials were to be anticipated, and whether conditions could be relieved by the substitution of cheaper materials for more expensive. It also appeared that if the facts were known concerning the normal consumption, the prospective producer of raw materials would have valuable information concerning the advisability of developing new sources of supply.

In the collection of statistics the writer is indebted to Mr. G. H. Hecke, State Commissioner of Horticulture. Through his office, reports were received from 28 county horticultural commissioners, representing 71.67 per cent of the total acreage of fruits in the state, exclusive of grapes. These reports have been compiled and are shown in Table I. It seems reasonable to

¹ Address before the California Section of the American Chemical Society, San Francisco, January 12, 1918.

² The term "economic poisons" was suggested by the writer's associate, Mr. M. R. Miller, as being appropriate in referring to the diversified and yet closely related group of materials used for the control of weeds, insects, fungi, and rodents. The qualifying word "economic" serves to distinguish between poisons which are made to serve useful purposes in the control of pests, and the more popular conception of poisons as being harmful to man, and often used with criminal intent. *Science*, N. S., 44, No. 1185, 264.

assume that the consumption of economic poisons is roughly proportional to the acreage of fruits. The figures shown in the last column of Table I are estimated on that basis.

While it is known that there are inaccuracies in the reports submitted, it is believed that the information received from them is of sufficient value to warrant its publication. It will be noticed that many of the materials listed have important uses other than as economic poisons, but so far as possible the amounts represent only that consumed in the control of pests. The commissioners went to unusual pains in segregating the amounts used in that way.

In order that these data may be more intelligible to producers of raw materials, some of the more important items have been reduced to tons of raw materials required for their production, or of the better-known commodities which are quoted in the New York market, and are given in Table II.

COMMENTS

Extended comment will not be made at this time on the situation as a whole, but only such observations as seem justified by the information at hand.

ARSENICALS—It is interesting to note that of the 6000 odd tons of white arsenic normally consumed in the United States, about one-sixtieth was used in California alone in the control of insects. Aside from the use of arsenic in the control of insects, some little interest is now being taken in the possible utility of arsenicals in the control of weeds. During the past year there were used in California about three tons of white arsenic in weed control experiments.

The unusual fluctuation in the price of arsenic during the period of the war has caused no little apprehension concerning the adequacy of the supply of this material. The New York price of white arsenic at one time was five hundred per cent above normal. In January 1918 it was still quoted four hundred per cent above normal. The reason commonly assigned for the high prices of arsenic is that the importations, which usually amount to about 3000 tons annually, have been stopped, thus depleting the stocks on hand and severely taxing the output of domestic producers, which is normally about equal to the imports. It is believed, however, that many times more than the normal consumption of arsenic in the United States can be produced as a by-product from smelter smoke and that the high price of arsenic is artificial. It is sincerely to be hoped that the government control will relieve the situation in respect to this very important economic poison.

COPPER SULFATE—The price of this raw material for the preparation of copper fungicides was for a short time nearly four times normal, but during the past year, it has been slightly less than double. The great demand for copper during the war will hold the price high, although not as high as many other chemicals. Much of it is a by-product in the production of other materials and uses up copper which is not salable in other forms. Sulfur fungicides have been substituted for copper compounds to a large extent, where possible.

SULFUR—Sulfur prices held practically normal until after declaration of war by the United States, but are now about one hundred per cent above normal. Reliable information indicates that this country may face an actual shortage of sulfur. Enormous quantities of pyrites are used in the manufacture of sulfuric acid, much of this being imported from Spain. Importations have now ceased, so that the sulfuric acid plants are obliged to use sulfur or obtain local pyrites. The American producers of sulfur are developing new deposits and it is reported that promising deposits of pyrites are being investigated by the Government so that production may meet consumption.

SODIUM CYANIDE—A shortage of sodium cyanide for fumigating citrus trees, and other purposes, occurred during the fumigating

TABLE I—CONSUMPTION AND COST OF ECONOMIC POISONS IN CALIFORNIA IN 1916

MATERIAL	Consumption in 28 counties reporting	Average price to consumer Dollars	Cost in 28 counties reporting Dollars	Totals in 28 counties reporting Dollars	Estimated totals for entire state Dollars
White Arsenic.....	14,686 lbs.	0.183	2,688		
Paris Green.....	13,616 lbs.	0.435	5,923		
Lead Arsenate, Paste.....	633,428 lbs.	0.110	69,677		
Lead Arsenate, Dry.....	100,067 lbs.	0.225	22,515		
Zinc Arsenite.....	32,575 lbs.	0.300	9,772		
ARSENICALS.....				110,575	154,284
Copper Sulfate.....	729,850 lbs.	0.142	103,639		
Bordeaux Pastes.....	103,754 lbs.	0.124	12,865		
Bordeaux Powders.....	37,625 lbs.	0.120	4,515		
COPPER COMPOUNDS.....				121,019	168,856
Sodium Cyanide.....	2,119,557 lbs.	0.284	601,954		
Sulfuric Acid.....	3,682,306 lbs.	0.017	62,599		
CYANIDE AND ACID.....				664,553	927,240
Sulfur.....	4,514,103 lbs.	0.037	167,022		
Coml. Lime-sulfur.....	18,201 bbls.	9.957	181,287		
Sulfur Pastes.....	160,536 lbs.	0.082	13,164		
Sodium Sulfide.....	121,023 lbs.	0.080	9,682		
SULFUR AND COMPOUNDS.....				371,155	517,867
Kerosene.....	58,448 gals.	0.106	6,254		
Other Petrol, Dist.....	125,701 gals.	0.065	8,171		
Crude Petroleum.....	254,670 gals.	0.043	10,840		
Coml. Emulsions.....	286,400 gals.	0.106	30,358		
Miscible Oils.....	40,400 gals.	0.283	11,433		
Coal-tar "Dips".....	11,637 gals.	1.200	13,964		
OILS AND EMULSIONS.....				81,020	113,046
Fish-Oil Soap, Hard.....	203,918 lbs.	0.047	9,584		
Fish-Oil Soap, Liquid.....	59,669 lbs.	0.067	3,998		
Coml. Emulsifiers.....	3,700 gals.	0.400	1,480		
Soap Powders.....	600,729 lbs.	0.040	14,019		
SOAPS AND EMULSIFIERS.....				29,081	40,576
Quicklime.....	5,454 bbls.	2.100	11,453		
Hydrated Lime.....	337,202 lbs.	0.011	3,709		
Caustic Soda and Lye.....	508,169 lbs.	0.070	35,572		
LIME AND CAUSTICS.....				50,734	70,788
Tobacco Leaves.....	55,175 lbs.	0.036	1,986		
Tobacco Extracts.....	60,224 lbs.	1.033	62,211		
TOBACCO AND EXTRACTS.....				64,197	89,573
Strychnine.....	16,979 ozs.	1.102	18,711		
Formaldehyde.....	9,065 gals.	2.091	18,955		
Carbon Bisulfide.....	56,741 gals.	1.603	90,956		
Pyrethrum.....	7,724 lbs.	0.971	6,400		
Quassia.....	103 lbs.	0.220	23		
Hellebore.....	666 lbs.	0.404	269		
Iron Sulfate.....	75,527 lbs.	0.056	4,230		
Corrosive Sublimate.....	1,951 lbs.	1.824	3,559		
Cost of Standard Remedies.....				1,635,437	2,281,899
Cost of Proprietary Preparations.....				133,856	186,767
TOTAL.....				\$1,769,293	\$2,468,666

season of 1916. There was an ample supply during the past season, owing to the output of new plants which started operations.

CARBON BISULFIDE—Carbon bisulfide is rather a novelty in the chemical line, as its price has been scarcely affected by the war. It was quoted in New York at 6½ cents in January 1914 and at 7½ cents in January 1918, this being scarcely more than the normal fluctuation. This fact is especially gratifying in view of the fact that this is the most important fumigant for use in the control of insects infesting stored grain, beans, and many other products. It is also the most approved material for the winter control of ground squirrels.

TABLE II—RAW MATERIALS REQUIRED FOR THE PREPARATION OF SOME OF THE MORE IMPORTANT ECONOMIC POISONS CONSUMED IN CALIFORNIA DURING THE YEAR 1916

White Arsenic.....	105 tons
Blue Vitriol.....	558 tons
Litharge.....	187 tons
Zinc.....	11 tons
Acetic Acid.....	1 ton
Sodium Cyanide.....	1,479 tons
Sulfuric Acid (66° Baumé).....	2,569 tons
Sulfur.....	4,988 tons
Crude Petroleum and Distillates.....	954,000 gals.
Coal-tar Creosote.....	12,000 gals.
Soaps (chiefly fish-oil and soap powders).....	777 tons
Cresol.....	9 tons

RODENT POISONS—Strychnine is now selling about two hundred per cent above normal. Saccharine, used as a "camouflage" in strychnine-coated barley to mask the intensely bitter taste of the strychnine, is now being quoted at over \$50 per lb. and at times is very difficult to obtain at any price. Some other equally effective, but cheaper "camouflage" is much needed for use in preparing squirrel and gopher poisons.

INCREASED CONSUMPTION—The commissioners were asked to

give an estimate of any probable increase or decrease in the demand for economic poisons in the future. Not enough of the commissioners, however, were willing to venture an estimate for one to foresee the future in this respect. The agriculturist has so many problems staring him in the face for solution—labor, high price of supplies, marketing, etc.—that he, himself, is scarcely able to predict whether or not his efforts at pest control will have to be relaxed, as we go deeper and deeper into the war, or whether this vital factor in the production of most foodstuffs can be given even greater attention than in the past.

It is quite certain that the consumption of rodent poisons, strychnine, saccharine, and carbon bisulfide, will be enormously increased in California during 1918. In the interest of the public health and in the conservation of the agricultural resources of the state, all federal, state, and county organizations concerned are making a united and special effort in a state-wide campaign against the ground squirrel.

It seems quite unlikely that the consumption of the other economic poisons will be less in the future than in the past. In fact, there are many reasons for anticipating a greater demand: the coming into bearing of new acreages of fruit; more extensive inter-cropping; higher prices for farm products, especially, wheat, beans, etc., which heretofore had been so low as to discourage, in a large measure, the control of pests. Control measures will now in many cases be profitable which ordinarily are unprofitable. Let us hope that the prices of the economic poisons will not be artificially inflated, and that the agriculturist will not be unduly exploited by the "profiteer."