EVALUATION OF THE HEALTH ASPECTS OF SODIUM HYDROXIDE
AND POTASSIUM HYDROXIDE AS FOOD INGREDIENTS

1976

Prepared for

Bureau of Foods
Food and Drug Administration
Department of Health, Education, and Welfare
Washington, D.C.

Contract No. FDA 223-75-2004
EVALUATION OF THE HEALTH ASPECTS OF SODIUM HYDROXIDE
AND POTASSIUM HYDROXIDE AS FOOD INGREDIENTS

1976

Prepared for

Bureau of Foods
Food and Drug Administration
Department of Health, Education, and Welfare
Washington, D.C.

Contract No. FDA 223-75-2004

Life Sciences Research Office
Federation of American Societies
for Experimental Biology
9650 Rockville Pike
Bethesda, Maryland 20014

68
NOTICE

This report is one of a series concerning the health aspects of using the Generally Recognized as Safe (GRAS) or prior sanctioned food substances as food ingredients, being made by the Federation of American Societies for Experimental Biology (FASEB) under contract no. 223-75-2004 with the Food and Drug Administration (FDA), U.S. Department of Health, Education, and Welfare. The Federation recognizes that the safety of GRAS substances is of national significance, and that its resources are particularly suited to marshalling the opinions of knowledgeable scientists to assist in these evaluations. The Life Sciences Research Office (LSRO), established by FASEB in 1962 to make scientific assessments in the biomedical sciences, is conducting these studies.

Qualified scientists were selected as consultants to review and evaluate the available information on each of the GRAS substances. These scientists, designated the Select Committee on GRAS Substances, were chosen for their experience and judgment with due consideration for balance and breadth in the appropriate professional disciplines. The Select Committee's evaluations are being made independently of FDA or any other group, governmental or nongovernmental. The Select Committee accepts responsibility for the content of each report. Members of the Select Committee who have contributed to this report are named in Section VII.

Tentative reports are made available to the public for review in the Office of the Hearing Clerk, Food and Drug Administration, after announcement in the Federal Register, and opportunity is provided for any interested person to appear before the Select Committee at a public hearing to make oral presentation of data, information, and views on the substances covered by the report. The data, information, and views presented at the hearing are considered by the Select Committee in reaching its final conclusions. Reports are approved by the Select Committee and the Director of LSRO, and subsequently reviewed and approved by the LSRO Advisory Committee (which consists of representatives of each constituent society of FASEB) under authority delegated by the Executive Committee of the Federation Board. Upon completion of these review procedures the reports are approved and transmitted to FDA by the Executive Director of FASEB.

While this is a report of the Federation of American Societies for Experimental Biology, it does not necessarily reflect the opinion of all of the individual members of its constituent societies.

C. Jelleff Carr, Ph.D., Director
Life Sciences Research Office
FASEB
<table>
<thead>
<tr>
<th>CONTENTS</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.  Introduction</td>
<td>1</td>
</tr>
<tr>
<td>II.  Background information</td>
<td>2</td>
</tr>
<tr>
<td>III. Consumer exposure data</td>
<td>3</td>
</tr>
<tr>
<td>IV.  Biological studies</td>
<td>6</td>
</tr>
<tr>
<td>V.   Opinion</td>
<td>9</td>
</tr>
<tr>
<td>VI.  References cited</td>
<td>11</td>
</tr>
<tr>
<td>VII. Scientists contributing to this report</td>
<td>14</td>
</tr>
</tbody>
</table>
I. INTRODUCTION

This report concerns the health aspects of using sodium hydroxide, and potassium hydroxide as food ingredients. It has been based partly on the information contained in a scientific literature review (monograph) furnished by FDA (1), which summarizes the world's scientific literature from 1920 through 1974.* To assure completeness and currency as of the date of this report this information has been supplemented by searches of over 30 scientific and statistical reference sources and compendia that are generally available; use of new, relevant books and reviews and the literature citations contained in them; consideration of current literature citations obtained through computer retrieval systems of the National Library of Medicine; searches for relevant data in the files of FDA; and by the combined knowledge and experience of members of the Select Committee and the LSRO staff. In addition, an announcement was made in the Federal Register of January 7, 1977 (42 FR 1519 to 1521) that opportunity would be provided for any interested person to appear before the Select Committee at a public hearing to make oral presentation of data, information and views on the health aspects of using sodium hydroxide, and potassium hydroxide as food ingredients. The Select Committee received no requests for such a hearing on sodium hydroxide, and potassium hydroxide.

As indicated in the Food, Drug, and Cosmetic Act [21 USC 321 (s)], GRAS substances are exempt from the premarketing clearance that is required for food additives. It is stated in the Code of Federal Regulations 21 CFR 121.1, revised April 1, 1976, that GRAS means general recognition of safety by experts qualified by scientific training and experience to evaluate the safety of substances on the basis of scientific data derived from published literature. This section of the Code also indicates that expert judgment is to be based on the evaluation of results of credible toxicological testing or, for those substances used in food prior to January 1, 1958, on a reasoned judgment founded in experience with common food use, and is to take into account reasonably anticipated patterns of consumption, cumulative effects in the diet, and safety factors appropriate for the utilization of animal experimentation data. FDA recognizes further (21 CFR 121.3) that it is impossible to provide assurance that any substance is absolutely safe for human consumption.

*The document (PB-234 899/3) is available from the National Technical Information Service, U.S. Department of Commerce, P.O. Box 1553, Springfield, Virginia 22161.
The Select Committee on GRAS Substances of LSRO in making its evaluations of these substances in full recognition of the foregoing provisions. In reaching its conclusions on safety the Select Committee, in accordance with FDA's guidelines, is relying primarily on the absence of substantive evidence of, or reasonable grounds to suspect, a significant risk to the public health. While the Select Committee realizes that a conclusion based on such reasoned judgment is expected even in instances where the available information is qualitatively or quantitatively limited, it recognizes that there can be instances where, in the judgment of the Select Committee, there are insufficient data upon which to base a conclusion. The Select Committee, aware that biological testing is dynamic, bases its conclusions on information now available; it cannot anticipate the results of experiments not yet conducted or those of tests that may be reconduted, using new technologies. These conclusions will need to be reviewed as new or better information becomes available.

In this context, the LSRO Select Committee on GRAS Substances has reviewed the available information on sodium hydroxide and potassium hydroxide and submits its interpretation and assessment in this report, which is intended for the use of FDA in determining the future status of these substances under the Federal Food, Drug, and Cosmetic Act.

II. BACKGROUND INFORMATION

Sodium and potassium hydroxides (NaOH and KOH) are white, highly deliquescent, caustic solids which are marketed as pellets, flakes and powder in varying degrees of purity. They are very soluble in water, ethyl alcohol, and glycerin forming strongly alkaline solutions. Both compounds rapidly absorb moisture and carbon dioxide when exposed to air.

As described in the Food Chemicals Codex (2), food grade sodium hydroxide must assay not less than 95 percent total alkali, calculated as NaOH; solutions must assay not less than 97 percent nor more than 103 percent by weight of the labeled amount of NaOH calculated as total alkalinity. Food grade potassium hydroxide must assay not less than 85 percent of total alkali, calculated as KOH; solutions must be not less than 97 percent and not more than 103 percent by weight of the labeled amount of KOH, calculated as total alkalinity. The limits of impurities for both sodium hydroxide and potassium hydroxide are:
<table>
<thead>
<tr>
<th>Substance</th>
<th>ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic (as As)</td>
<td>3</td>
</tr>
<tr>
<td>Mercury</td>
<td>1</td>
</tr>
<tr>
<td>Lead</td>
<td>10</td>
</tr>
<tr>
<td>Heavy metals (as Pb)</td>
<td>30</td>
</tr>
<tr>
<td>Carbonates</td>
<td></td>
</tr>
<tr>
<td>NaOH</td>
<td>30,000 (as Na₂CO₃)</td>
</tr>
<tr>
<td>KOH</td>
<td>35,000 (as K₂CO₃)</td>
</tr>
</tbody>
</table>

The Code of Federal Regulations (3) lists sodium hydroxide and potassium hydroxide as miscellaneous and/or general purpose (GRAS) food additives [21 CFR 121.101(d)(8)]. They are used as buffering and neutralizing agents. Sodium hydroxide is also recognized as GRAS as a substance migrating to food from paper and paperboard products used in food packaging [21 CFR 121.101(h)], and as a substance migrating to food from cotton and cotton fabrics used in dry food packaging [21 CFR 121.101(i)]. Both sodium hydroxide and potassium hydroxide are regulated for use in the processing of cacao products as described in Part 14 of the Code of Federal Regulations. Sodium hydroxide is regulated for use in the processing of canned peas (21 CFR 51.1), in the processing of food starch-modified where it is not to exceed 1 percent (21 CFR 121.1031), and as a boiler water additive that may be safely used in the preparation of steam that will contact food (21 CFR 121.1088).

Food categories to which sodium and potassium hydroxides may be added as neutralizing agents are shown in Table I, taken from a report of a survey of a subcommittee of the National Research Council (NRC) (4). According to the processors that responded to that survey, potassium hydroxide was first reported to be used in 1876 in foods in the United States; sodium hydroxide was first reported to be used in 1946.

III. CONSUMER EXPOSURE DATA

The NRC subcommittee survey of food manufacturers (4) has also provided information on the levels of addition of sodium hydroxide and potassium hydroxide to foods in several food categories (Table I). Based on information supplied by manufacturers who reported adding the substances to at least one food in a category, weighted means were calculated for the usual and maximal addition of sodium hydroxide and potassium hydroxide to foods in that category. Only the weighted means of the usual levels of addition are reported in Table I.
TABLE I

Level of Addition of Sodium and Potassium Hydroxides to Foods

by Food Category (4)

<table>
<thead>
<tr>
<th>Food category</th>
<th>Sodium hydroxide weighted mean percent</th>
<th>Potassium hydroxide weighted mean percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baked goods, baking mixes</td>
<td>0.003</td>
<td>0.006</td>
</tr>
<tr>
<td>Breakfast cereals</td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>Grain products such as pastas, or rice dishes</td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>Fats and oils</td>
<td>0.020</td>
<td></td>
</tr>
<tr>
<td>Milk, milk products</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>Cheese</td>
<td>0.002</td>
<td>0.119</td>
</tr>
<tr>
<td>Frozen dairy desserts, mixes</td>
<td>0.152</td>
<td></td>
</tr>
<tr>
<td>Meat products</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Processed vegetables, juices</td>
<td>0.361</td>
<td></td>
</tr>
<tr>
<td>Soft candy</td>
<td>0.008</td>
<td></td>
</tr>
<tr>
<td>Sugar, confections</td>
<td>0.034</td>
<td></td>
</tr>
<tr>
<td>Sweet sauces, toppings, syrups</td>
<td>0.020</td>
<td></td>
</tr>
<tr>
<td>Gelatins, puddings, fillings</td>
<td>0.400</td>
<td></td>
</tr>
<tr>
<td>Beverages, nonalcoholic</td>
<td>&lt;0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>Beverages, alcoholic</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Reconstituted vegetable proteins</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Gravies, sauces</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Dairy products analogs</td>
<td>0.017</td>
<td></td>
</tr>
<tr>
<td>Instant coffee and tea</td>
<td>***</td>
<td>0.055</td>
</tr>
<tr>
<td>Baby formulas</td>
<td>0.037</td>
<td>0.054</td>
</tr>
</tbody>
</table>

Blanks in the table mean that the substance is not added to the foods indicated; asterisks (*** ) in the table mean that (a) the substance is used in a processing phase of the foods indicated but residual levels in the final food product are negligible or unknown, or (b) the substance is used in the foods indicated but usage levels were not furnished by industry, or (c) the substance is in the foods indicated but the levels were considered to be reported incorrectly (see explanatory notes in exhibit 50 of reference 4).
The NRC subcommittee estimated possible daily average intakes of sodium hydroxide and potassium hydroxide (Table II) from Market Research Corporation of America data on the mean frequency of eating foods by food category, U. S. Department of Agriculture data on mean portion size of foods in these categories, and the assumption that all food products within a category contain the substances at the level shown in Table I. Such an assumption is likely to lead to overestimates of intake. The NRC subcommittee has recognized that in most cases its calculations of possible intakes are overstated, often by considerable margins. Because of factors detailed in Section XI of the subcommittee's report (4) it stated that the possible average estimated total dietary intakes are likely to be much higher than would be the intakes achieved through consumption of a diet consisting totally of processed foods to which the substances had been added at the maximum levels.

**TABLE II**

Possible Daily Intake of Sodium Hydroxide and Potassium Hydroxide by Age Group (4)

<table>
<thead>
<tr>
<th>Age group</th>
<th>Sodium hydroxide mg</th>
<th>Potassium hydroxide mg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mg/kg</td>
<td>mg/kg</td>
</tr>
<tr>
<td>0-5 mo</td>
<td>139</td>
<td>182</td>
</tr>
<tr>
<td>6-11 mo</td>
<td>181</td>
<td>45</td>
</tr>
<tr>
<td>12-23 mo</td>
<td>232</td>
<td>28</td>
</tr>
<tr>
<td>2-65+ yrs</td>
<td>439</td>
<td>87</td>
</tr>
</tbody>
</table>

a It should be noted that the figures in this table represent amounts of sodium and potassium hydroxides added to the foods for pH adjustment during processing and not the amounts consumed as such. The caustic properties of these substances are well known. However, neither alkali per se remains in foods as ingested since each is converted to the neutral salt during processing by reaction with food acids. Equivalent Na intakes calculated for the four age groups are 80, 104, 133, and 252 mg, respectively; equivalent K intakes are 127, 31, 19, and 61 mg, respectively.

b Calculated intake, mg per kg body weight, was based on an average weight of 60 kg for an adult (5) and the following estimated weights of infants by age groups: 0-5 mo, 5 kg; 6-11 mo, 8 kg; and 12-23 mo, 11 kg (6).

An estimate of the per capita daily consumption of NaOH and KOH equivalents can be made also from the NRC survey data (4) on the quantities reported to be used in foods in 1970 (Table III). The per capita daily intakes of the equivalent of 160 mg of sodium hydroxide, and 12 mg of potassium hydroxide...
are about 0.4 and 0.1, respectively, of the figures given in Table II for the 2 to 65+ year age group. The Table III figures are considered by the Select Committee to be more typical of the average daily intakes of this age group.

### TABLE III

**Total Quantity of Sodium and Potassium Hydroxides Used Annually in Foods (4)**

<table>
<thead>
<tr>
<th>Substance</th>
<th>Relative amounts used(^a) 1970/1960</th>
<th>Total used(^b) (1970) kg</th>
<th>Per capita daily intake(^c) mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium hydroxide</td>
<td>1.6</td>
<td>12,000,000</td>
<td>160</td>
</tr>
<tr>
<td>Potassium hydroxide</td>
<td>2.2</td>
<td>870,000</td>
<td>12</td>
</tr>
</tbody>
</table>

\(^a\) Based only on the reports from those respondents to the NRC survey who submitted information for both 1960 and 1970.

\(^b\) Total usage is based on the sum of kilograms used in foods reported by NRC and the Flavor and Extract Manufacturers' Association (FEMA) recalculated to 100 percent from survey data that the NRC subcommittee estimated to represent about 60 percent of the actual usage.

\(^c\) Based on the quantities indicated in Column 2 and a United States population of 205 million.

### IV. BIOLOGICAL STUDIES

**Absorption, distribution, biotransformation, excretion**

The corrosive effects of ingestion of large amounts of alkali are well known (7). However, at the levels added, it is obvious that both sodium and potassium hydroxide will be neutralized by food acids when added during processing. The Joint Expert Committee on Food Additives considers sodium and potassium hydroxides as acceptable when used in food processing in accordance with good manufacturing practice, provided the increased dietary load of sodium or potassium ions is assessed and considered acceptable (8). The Food and Nutrition Board of the National Research Council (9) has reviewed data on the usual daily adult intakes of sodium and potassium from all dietary sources and found the best estimates to be 2.3 to 6.9 g for sodium and 2 to 5.9 g for potassium. Homeostatic mechanisms allow wide variations. The Select Committee believes that the amounts of sodium and potassium hydroxides usually used in preparing foods (Table I) do
not pose metabolic or excretory problems for normal individuals with respect to sodium and potassium. The amounts of sodium and potassium that could be contributed to the diet by the sodium and potassium hydroxides added to foods, are clearly small in relation to the usual total intakes of sodium and potassium. However, the amount of sodium hydroxide added to processed foods, expressed on a per capita basis, is 160 mg (Table III). For individuals adhering to diets restricted in sodium, that is, about 250 mg per day (10), the amounts of this element consumed as a result of sodium hydroxide addition to processed foods, might constitute a significant percentage of their total sodium intake.

Acute and short-term toxicity studies

The oral lethal dose of sodium hydroxide in rabbits is reported to be 500 mg per kg (11) and the oral LD_{50} of potassium hydroxide in rats 1,230 mg per kg (12).

Fazekas (13) found that the oral administration of single doses of 0.5 to 2.5 g sodium hydroxide (equivalent to 147 mg to 943 mg per kg body weight) to rabbits was followed by restlessness, stretching out, jumping or rolling about, increased respiration, incontinence, gradual decrease in activity resulting in a motionless state, weakness, slower and weaker respiratory and cardiac activity culminating in death in 7 hours to 14 days in most animals. Three animals receiving respectively, 147, 210, and 429 mg per kg of body weight, survived beyond 14 days. Fazekas (13) also noted increases in blood glucose and inorganic phosphorus; and decreases in serum calcium, chloride, and sodium after dosing. Tissue sections, fixed immediately after death, revealed fat emboli in 94 percent of the rabbits treated, appearing as early as seven hours after treatment and as late as nine to twelve days post-treatment. The emboli were most prevalent (91 percent of the animals) and most severe in the lungs; 50 to 70 percent of the animals had emboli in the choroid plexus; 20 percent in the kidneys; and 5 to 10 percent in the liver, spleen, and heart. The author suggests that fat emboli, due to lipemia, may have been the cause of death.

At necropsy, Steyn (14) observed corrosion of gastric mucosa and perforation of stomach wall in rabbits receiving massive oral doses (5 to 12 g per kg body weight) of sodium hydroxide administered as 10 to 20 percent solutions in cow's milk.

Heller (15) administered 0.5 or 1.0 percent sodium hydroxide solution to rats as their drinking water. Age and weight of animals and duration of the experiment were not indicated, but it is estimated that daily intakes of sodium hydroxide could be of the order of 700 to 1,500 mg per kg of body weight. At the lower intake level, growth was found to be practically normal, whereas little growth was observed at the higher intake level. None of the females conceived at either dosage level.
In experiments conducted to study the effects of delignification of forages on their digestibility (16, 17) calves were fed wheat straw sprayed with 3.3, 6.7, and 10 percent solutions of sodium hydroxide. The unwashed treated straws were then mixed with peanut meal, molasses and mineral supplement. Animals consuming the straw treated with 10 percent alkali had an estimated daily intake equivalent to about 7 g NaOH per kg body weight. The animals remained in good health throughout the 12 week experiment and gained weight. No adverse effects were observed after feeding any of the alkali treated straws.

**Acute human toxicity**

Willimott and Gosden (18) estimated from observation of a series of accidental and intentional poisoning cases that the fatal dose of sodium hydroxide is less than 10 g, although 5 g (about 80 mg per kg) was found to cause severe esophageal stricture. Arena (7) has reported that esophageal strictures often develop in non-fatal cases of ingestion of sodium and potassium hydroxides, and the importance of early dilation to prevent esophageal strictures in the management of acute sodium hydroxide intoxication has been emphasized by Kernodle et al (19).

In work conducted by Castell and Levine (20) 28 human subjects with normal pressure at the lower esophageal sphincter and six with abnormally low esophageal pressures received 0.1 N NaOH (about 20 to 40 mg per minute over a period of 20 minutes) via stomach tube. The total dose was approximately 640 mg or about 10 mg per kg body weight. Sodium hydroxide administration resulted in a marked increase in lower esophageal sphincter pressure in all subjects. No adverse effects were reported. As a result of this study the authors suggest that alkaline antacids act both by neutralizing gastric acid and by increasing the lower esophageal sphincter pressure barrier.

**Carcinogenicity**

In 1925, Narat (21) reported that the repeated (frequent but irregular) application of 3 to 6 percent solutions of potassium hydroxide or hydrochloric acid to the skin of two strains of mice over periods up to 46 weeks, elicited tumors which were indistinguishable from those caused by crude coal tar. These responses to tar, KOH, or HCl, were not observed in two other mouse strains tested. When Bogen and Loomis (22) painted mice with 10 percent NaOH, only one of the seven mice developed one benign tumor. Hydrochloric acid produced no tumors. Dyer et al. (23) intubated mice daily with a 0.5 N NaOH solution (dose equivalent to 200 mg NaOH per kg body weight per day), alone and in combination with 1,2,5,6-dibenzanthracene for 10 months. No cancers or precancerous
lesions were produced in the gastric mucosa under either experimental condition. No adverse effects were reported by Russell et al. (24) when female Wistar rats received about 1 mg NaOH per kg body weight by stomach tube three times weekly for 93 days. Complete necropsies were performed, including microscopic examination of all organs. Kimura and Makino (25) found that the intraperitoneal administration of potassium hydroxide (1.8 g per kg body weight) had little effect on MTK-sarcoma III ascites rat tumor cells previously placed in the abdominal cavity. However, KOH and most of the other 22 inorganic compounds tested, caused mitotic abnormalities in varying degrees. Arrants et al. (26), and Barbosa et al. (27) have suggested that carcinomas may develop in later years at the site of esophageal strictures caused by accidental ingestion of lye in childhood.

**Mutagenicity**

In studies by Demerec et al. (28) on the mutagenic action of various chemicals on *E. coli* (strain Sd-4), it was concluded that potassium and sodium hydroxides were not mutagenic.

V. OPINION

The Select Committee has found no data suggesting that the use of sodium or potassium hydroxides, as currently practiced in food processing, is hazardous to consumers. The corrosive effect of ingestion of large amounts of strong alkalis such as sodium and potassium hydroxides has been amply demonstrated. However, these alkalis are not present as such in foods as consumed. The small amounts added for pH adjustment during food processing react rapidly with food acids to form neutral salts. Moreover, any free alkali that might be present in food, either from direct addition or from migration from packaging materials, is rapidly converted to neutral salts in the stomach.

The amounts of sodium and potassium hydroxide used in food processing contribute only 2 to 5 percent of the total sodium and potassium intake from all dietary sources. Accordingly, these alkalis, as now used in food processing, do not add significantly to the usual dietary load of sodium and potassium.

In light of the foregoing, and the information elsewhere in this report, the Select Committee concludes that:
There is no evidence in the available information on potassium hydroxide or sodium hydroxide that demonstrates, or suggests reasonable grounds to suspect a hazard to the public, when they are used at levels that are now current or that might reasonably be expected in the future.

There is no evidence in the available information on sodium hydroxide that demonstrates, or suggests, reasonable grounds to suspect a hazard to the public when it is used as an ingredient of food packaging materials in the manner now practiced or that might reasonably be expected in the future.
VI. REFERENCES CITED


VII. SCIENTISTS CONTRIBUTING TO THIS REPORT

1. Members of the Select Committee on GRAS Substances:

Joseph F. Borzelleca, Ph.D., Professor of Pharmacology, Medical College of Virginia, Health Sciences Division, Virginia Commonwealth University, Richmond, Va.

Harry G. Day, Sc.D., Professor Emeritus of Chemistry, Indiana University, Bloomington, Ind.

Samuel J. Fomon, M.D., Professor of Pediatrics, College of Medicine, University of Iowa, Iowa City, Iowa.

Bert N. La Du, Jr., M.D., Ph.D., Professor and Chairman, Department of Pharmacology, University of Michigan Medical School, Ann Arbor, Mich.

John R. McCoy, V.M.D., Professor of Comparative Pathology, New Jersey College of Medicine and Dentistry, Rutgers Medical School, New Brunswick, N.J.

Sanford A. Miller, Ph.D., Professor of Nutritional Biochemistry Massachusetts Institute of Technology, Cambridge, Mass.

Gabriel L. Plaa, Ph.D., Professor and Chairman, Department of Pharmacology, University of Montreal Faculty of Medicine, Montreal, Canada.

Michael B. Shimkin, M.D., Professor of Community Medicine and Oncology, School of Medicine, University of California, San Diego, La Jolla, Calif.

Ralph G.H. Siu, Ph.D., Consultant, Washington, D.C.

John L. Wood, Ph.D., Distinguished Service Professor, Department of Biochemistry, University of Tennessee Medical Units, Memphis, Tenn.

George W. Irving, Jr., Ph.D. (Chairman), Research Associate, Life Sciences Research Office, Federation of American Societies for Experimental Biology, Bethesda, Md.
2. LSRO staff:

C. Jelleff Carr, Ph.D., Director
Kenneth D. Fisher, Ph.D., Associate Director
Richard G. Allison, Ph.D., Research Associate
Samuel B. Detwiler, Jr., Research Associate
Andrew F. Freeman, Research Associate
Frederic R. Senti, Ph.D, Research Associate
John M. Talbot, M.D., Research Associate

Report submitted by:

March 16, 1977

George W. Irving, Jr., Chairman
Select Committee on GRAS Substances