EVALUATION OF THE HEALTH ASPECTS OF PECTIN
AND PECTINATES AS FOOD INGREDIENTS

1977

Prepared for

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

Contract No. FDA 223-75-2004
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Life Sciences Research Office
Federation of American Societies for Experimental Biology
9650 Rockville Pike
Bethesda, Md. 20014

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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.

/Kenneth D. Fisher, Ph.D., Director
Life Sciences Research Office
FASEB

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I. INTRODUCTION

This report concerns the health aspects of using pectin and pectinates 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 1973. * 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 June 3, 1977 (42 FR 28600-28601) 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 pectin and pectinates as food ingredients. The Select Committee received no requests for such a hearing on pectin and pectinates.

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 Act and in the Code of Federal Regulations (2) [21 CFR 170.3 and 170.30] 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. These sections of the Code also indicate 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 (2) recognizes further that it is impossible to provide assurance that any substance is absolutely safe for human consumption.

*The document (PB-230 306/3) is available from the National Technical Information Service, U.S. Department of Commerce, P.O. Box 1552, Springfield, Virginia 22161.
The Select Committee on GRAS Substances of LSRO is 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 reconducted, 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 pectin and pectinates 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

Pectin is a complex polysaccharide composed chiefly of linear (1→4)-linked α-D-galactopyranosyluronic acid units. Some of the carboxyl groups are present as the methyl ester, some are neutralized with cations and some are free acids. A few of the hydroxyl groups at positions C-2 and C-3 may be esterified with acetic acid. Although D-galacturonic acid is the major component, varying amounts of D-galactose, L-arabinose, and L-rhamnose also are usually present. Rhamnose and part of the arabinose and galactose appear to be integral parts of the galacturonan polymer; the remainder of the galactose and arabinose appears to be a constituent of galactan and arabinan polymers. The proportion of these neutral polysaccharides in commercial pectins is usually small because of their breakdown during extraction and other processing steps (3-5).

According to definitions adopted by the American Chemical Society (6), products which are essentially completely deesterified and composed mostly of colloidal polygalacturonic acids with varying degrees of neutralization are referred to as pectic acids. Salts of pectic acid are termed pectates. The term pectinic acids designates colloidal polygalacturonic acids containing more than a negligible content of methyl ester groups with varying degrees
of neutralization. The salts of pectinic acid are called pectinates. The term pectins designates those water soluble pectinic acids of varying methyl ester content and degree of neutralization that are capable of forming gels with sugar and acid under suitable conditions.

Pectin and pectinates are multiple purpose GRAS food substances [21 CFR 187.1775] or are prior-sanctioned food ingredients (2,7). Identity standards that permit addition of pectin as a thickening, emulsifying or gelling agent include those for ice cream, ice milk, water ices, non-fruit sherbets, non-fruit water ices, artificially sweetened canned fruits, French dressing, salad dressing, fruit jellies, preserves and jams (8).

In addition to its food applications, pectin has been used alone or in combination with other ingredients in pharmaceutical preparations for the treatment of diarrhea. Combination preparations include pectin-agar and pectin-kaolin (9).

Pectins are present in the cell walls of all green land plants. Among food sources, fruits and vegetables have the highest pectin content and may contain 0.5 to 4 percent on a fresh weight basis (9). The main industrial raw material for pectin production is citrus peel, principally lemon and lime, which contain from 20 to 40 percent pectin on the dry basis. Apple pomace, the residue remaining from the pressing of apples to obtain apple juice, also is a commercial source of pectin. Pectin is produced commercially by extraction of the raw material with water acidified to pH 1.5 to 3, usually with hydrochloric or sulfuric acid. The extract, separated by filtration or centrifugation, may be spray- or roller-dried to obtain a dry product. Alternatively, pectin may be precipitated with alcohol and dried, or precipitated as an insoluble aluminum or copper salt followed by washing with acidified alcohol to remove salts, and dried. The precipitation methods give a purer product and are most used by industry (3, 10).

The degree of esterification of pectin is a major factor in determining its properties as a gelling or stabilizing agent, its principal food uses. Pectins extracted under mild conditions may have 75 percent or more of their carboxyl groups esterified. For the preparation of many food products, a lower methoxyl content is required and deesterification to the desired degree is accomplished by appropriate acid, base or enzymic treatment (10). For base-catalyzed deesterification, ammonia is commonly employed and concurrent with deesterification, some amidation occurs (11). The low methoxyl pectins (methoxyl content about 2 to 7 percent) are usually neutralized with alkaline carbonates or hydroxides to give salts that are more stable than the free acid form.
Low ester pectins (2 to 7 percent methoxyl) and pectinic acids, in contrast to high ester pectins, do not require the presence of sugar to gel and find use in a variety of low sugar products. They do, however, require the presence of calcium or other divalent cations for gelation (3,10).

Specifications for food grade pectin are given in the Food Chemicals Codex (12). Included under the term pectin are high ester pectin (not less than 50 percent esterified), low ester pectin (not more than 50 percent esterified), amidated low ester pectin, pectinic acid and pectinates. Galacturonic acid content is required to be not less than 35 percent, arsenic not more than 3 ppm, heavy metals (as Pb) not more than 40 ppm, lead not more than 10 ppm and degree of amide substitution of low ester pectin not more than 40 percent. Sugars may be added to pectins in the standardization of gel grade, and buffer salts such as sodium citrate or sodium bicarbonate also may be added. Specifications for pharmaceutical grade pectin appear in the National Formulary (13).

The Joint FAO/WHO Expert Committee on Food Additives (14) considered non-amidated pectins and their salts as normal constituents of the human diet and placed no limitation on the acceptable daily intake of these products. For the amidated pectins, the acceptable daily intake was set at 0 to 25 mg per kg body weight.

III. CONSUMER EXPOSURE DATA

A survey by a National Research Council (NRC) subcommittee has provided information on the level of addition of pectin to foods in several food categories as given in Table I (15). Although information on the food use of sodium pectinate was requested in the survey, the respondents did not submit data on this substance. However, information on pectin usage was volunteered by some respondents to the survey. Based on information supplied by those manufacturers who reported adding pectin to at least one food in a category, a weighted mean was calculated for the usual and maximal addition of pectin to foods in each category. Only the weighted means of the usual level of addition are reported in Table I.

The NRC subcommittee also computed possible daily average human intakes of pectin (Table II) for each of the food categories based on the level of addition given in Table I, data from the Market Research Corporation of America on the frequency of eating foods in these food categories by individuals in four age groups, and U.S. Department of Agriculture data on mean portion size. Estimates for the 2 to 65+ year old age group are given in Table II. It should be noted that the pectin intake figures in Table II apply only to individuals who ate foods in the particular food category one or more
### TABLE I

Level of Addition of Pectin to Foods by Food Category (15)

<table>
<thead>
<tr>
<th>Food category</th>
<th>Weighted mean percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baked goods, baking mixes</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Fats and oils</td>
<td>0.40</td>
</tr>
<tr>
<td>Milk, milk products</td>
<td>0.13</td>
</tr>
<tr>
<td>Frozen dairy desserts, mixes</td>
<td>0.02</td>
</tr>
<tr>
<td>Processed fruits, juices, drinks</td>
<td>0.15</td>
</tr>
<tr>
<td>Fruit ices, water ices</td>
<td>0.15</td>
</tr>
<tr>
<td>Condiments, relishes, salt substitutes</td>
<td>0.20</td>
</tr>
<tr>
<td>Soft candy</td>
<td>0.77</td>
</tr>
<tr>
<td>Jams, jellies, sweet spreads</td>
<td>0.31</td>
</tr>
<tr>
<td>Sweet sauces, toppings, syrups</td>
<td>0.16</td>
</tr>
<tr>
<td>Gelatins, puddings, fillings</td>
<td>0.55</td>
</tr>
<tr>
<td>Gravies, sauces</td>
<td>0.07</td>
</tr>
</tbody>
</table>

### TABLE II

Possible Daily Intake of Added Pectin From Various Food Categories by Individuals Over Two Years of Age* (15)

<table>
<thead>
<tr>
<th>Food category</th>
<th>Intake of pectin mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baked goods, baking mixes</td>
<td>7</td>
</tr>
<tr>
<td>Fats and oils</td>
<td>70</td>
</tr>
<tr>
<td>Milk, milk products</td>
<td>75</td>
</tr>
<tr>
<td>Frozen dairy desserts, mixes</td>
<td>5</td>
</tr>
<tr>
<td>Processed fruits, juices, drinks</td>
<td>193</td>
</tr>
<tr>
<td>Fruit ices, water ices</td>
<td>17</td>
</tr>
<tr>
<td>Condiments, relishes, salt substitutes</td>
<td>22</td>
</tr>
<tr>
<td>Soft candy</td>
<td>88</td>
</tr>
<tr>
<td>Jams, jellies, sweet spreads</td>
<td>34</td>
</tr>
<tr>
<td>Sweet sauces, toppings, syrups</td>
<td>20</td>
</tr>
<tr>
<td>Gelatins, puddings, fillings</td>
<td>170</td>
</tr>
<tr>
<td>Gravies, sauces</td>
<td>9</td>
</tr>
</tbody>
</table>

*The figures in this table apply only to individuals who ate foods in the particular food category one or more times during the 14-day survey period, not to figures based on the amounts of food consumed by the entire survey population. The figures are valid for any particular substance on an individual food category basis only. They are not cumulative across all food categories, since no person could be expected to eat foods from all categories in any single day at the consumption levels shown.
times during the 14-day survey period, not to figures based on the amount of food consumed by the entire survey population. Also the figures are not additive across food categories for the reasons given in the table footnote. Insufficient data were available to permit the NRC subcommittee to estimate pectin intake from the total diet. However, U.S. production of pectin has been estimated to be 6.5 to 10 million pounds annually (3,16,17). About 10 percent of total pectin production in the United States and Western Europe in 1970 was low methoxyl pectin (18). Recent industry estimates (19,20) indicate that 7-3/4 million pounds of total pectin and 3/4 million pounds of low methoxyl pectin would be maximum values for the pectins currently used in foods in the United States. On the assumption that the population of the United States is 215 million, this amounts to a per capita value of 45 mg per day for total pectin and 4 mg per day for low methoxyl pectin. Because of wastage, actual per capita consumption values must be somewhat less. In view of the apparently wide distribution of pectin across various food categories (Table I), it seems unlikely that a minority of the population accounts for an unusually high percentage of pectin consumption. Therefore, the Select Committee considers the possible daily intakes listed in Table II (more than 45 mg per day in each of several food categories) to be extremely unlikely.

IV. BIOLOGICAL STUDIES

Absorption and metabolism

Kertesz (21) reported that a high ester pectin (88.4 percent galacturonic acid, 10.3 percent CH₃O) added to the diet of dogs and human subjects was decomposed in the alimentary canal to such degree that none could be isolated from the feces by precipitation with acidified alcohol. Saliva collected from human subjects, dogs and cows had no effect on the viscosity of the pectin after incubation for several weeks at pH 3.4 and 6.4. Similarly, jejunal juice collected from an isolated auto-transplanted segment in a dog did not decompose the high ester pectin. Pectin administered to a dog by stomach tube was essentially completely recovered (98.8 percent) through an enterostomy in the lower end of the jejunum after 160 minutes. Viscosity of the recovered pectin was unchanged. In vitro experiments showed no decomposition of pectin after 12 days incubation with trypsin, pepsin, rennet or pancreatic amylase. A suspension of human feces, however, decomposed the pectin as evidenced by low precipitability with calcium ion after one hour incubation. Addition of 1 percent of an active pectinase caused no further decrease in the quantity of calcium precipitate recovered.
Werch and Ivy (22) studied the digestibility of a citrus pectin (72.8 percent anhydrogalacturonic acid and 9.5 percent CH₃O) in dogs and humans. Recovery of pectin in the feces of four dogs fed 20 g of pectin daily for seven days in a low fiber diet was 3.4 percent by precipitation as calcium pectate and 8.9 percent by uronic acid analysis. Analysis of material from ileostomy bags of two dogs fed 20 g pectin mixed with cubed beef gave a recovery of 84.9 percent by the calcium pectate method and 88.3 percent by the uronic acid method. Pectin recovery from the feces of six human subjects fed 50 g pectin daily for three days as a component of a low fiber diet was 1.2 and 8.7 percent, respectively, by the same two methods. Recovery increased to 4.2 and 13.8 percent by the calcium pectate and uronic acid methods, respectively, when the pectin was fed to the human subjects during fasting. Fed to two humans who had been subjected to ileostomy operations, pectin recovery from the ileum excreta was 96.5 and 96.3 percent, respectively, by the two analytical methods.

Formic acid and acetic acids were the principal products isolated from a 1 percent solution of citrus pectin (72.8 percent uronic acid and 9.5 percent CH₃O) after incubation for two days with a suspension of dog feces (23). Yields were 0.3 g and 1.6 g per 10 g pectin, respectively. Only small quantities (19 mg per 10 g pectin) of galacturonic acid were found. Filtrates from washings of the stomach, duodenum, jejunum and three portions of the ileum of two dogs did not cause decomposition of pectin during a two-week incubation period.

Addition of 30 g of citrus pectin to the low fiber diet fed to six male students caused no increase in urinary excretion of galacturonic acid, reducing substances, formic acid or acetic acid during the third and fourth days on the diet. Similarly, no significant increase occurred in fecal excretion of formic and acetic acids (24).

Gilmore (25) reported the digestibility of low ester citrus pectin (3 to 5 percent methoxyl) was less than that of a high ester citrus pectin (N.F. grade, 10 to 12 percent CH₃O) as determined by recovery of galacturonic acid in the feces. Less than 1 percent of the high ester pectin, but 20 to 23 percent of the low ester pectin, was recovered from the excreta of weanling male Sprague-Dawley rats fed the pectins as 5 percent (about 5 g per kg body weight) of their diets. Furfural determinations were made on tissues of animals after 2, 4, 6, and 8 weeks of feeding as an indirect measure of possible absorption of pectin. There was a small but steady increase in furfural yield from the livers of rats fed high ester pectin but a decrease in the livers of those fed the low ester pectin. Furfural yield per 100 ml of blood paralleled these patterns. Gilmore concluded the evidence for absorption of pectin was weak.
Gädeken (26) determined the net energy yield of a high ester pectin by gravimetric measurement of gaseous exchange in respiration studies of eight resting adult male Wistar rats. Apparent digestibility coefficients were over 90 percent for pectin at the 12 and 24 percent levels (about 6 and 12 g per kg body weight) in the diet. However, net energy yield per gram of pectin was only 0.2 kcal for the 12 percent pectin ration and 0.8 kcal for the 24 percent pectin ration, representing 5.6 and 20.3 percent utilization, respectively, of the gross energy of pectin.

Viola et al. (27) concluded that both 65-percent-esterified and 55-percent-esterified citrus pectins were almost completely unabsorbed when fed as 5 and 10 percent (about 5 and 10 g per kg body weight) of the diet to weanling Charles River rats. Absorption was determined by comparison of pectin intake with the excess fecal weight of rats on the pectin diet over that on the basal diet which contained 5 or 10 percent starch. An apparent digestible energy of -1.6 kcal per g was calculated for both pectins from bomb calorimetric measurements on food and feces for the pectin and basal diets.

Using methodology similar to that of Viola et al. (27), Booth and coworkers (28) found the digestibility of pectin N.F. to be 19 percent in rats. They concluded, however, from a slight net loss in body weight after return to the basal diet that pectin was not utilized.

It would appear from the above experiments that pectin is degraded by the microflora in the colon and the degradation products are largely excreted in the feces.

**Acute toxicity**

With the exception of two reports concerning intravenous administration of pectin (29, 30), which the Select Committee does not consider relevant to the evaluation of use in foods, no reports on acute toxicity have been located.

**Short-term studies**

Groups of six Charles River weanling rats were fed diets containing 10 percent casein and 5 or 10 percent (about 5 and 10 g per kg body weight) of a slow-setting pectin (55 percent esterified) or a medium-rapid setting pectin (65 percent esterified) for 10 days (27). Food intake and growth were not depressed at the 5 percent level but both were significantly reduced on diets containing 10 percent of the pectins. Food intake and weight gain relative to the controls for the slow-setting pectin were 82.5 and 71.5 percent, respectively; those for the medium rapid-setting pectin were 70.5 and 52.0 percent, respectively. Apparent digestibility of protein was depressed in rats on the 10 percent pectin diets (79 percent as compared to 92.5 percent for the basal diet). Calcium retention was about 50 percent for the pectin
diets at both the 5 and 10 percent levels as compared to 75 percent for the basal diet.

No growth depression was reported in groups of four to six weanling rats fed, for eight weeks, diets containing 22 percent casein and 2.5, 5 or 10 percent N.F. citrus pectin (about 2.5 to 10 g per kg body weight). No gross deleterious effects were observed (31).

Groups of 50 weanling male Sprague-Dawley rats were fed diets containing 25 percent casein and 5 percent (5 g per kg body weight) citrus pectin N.F. (10 to 12 percent methoxyl) or low methoxyl citrus pectin (3.5 to 5 percent methoxyl) for eight weeks (25). Those fed the pectin N.F. consumed less diet and gained less weight than rats fed the basal diet. At six weeks the serum albumin of animals fed pectin N.F. had decreased, alpha-2 and gamma globulins had increased, and there was a marked retention of copper by the kidneys. At eight weeks the copper level had decreased but was still greater than the level in control animals. Serum albumin in rats receiving the low methoxyl pectin tended to decrease throughout the study and at eight weeks the alpha-2 globulin was markedly increased. Magnesium, phosphorus, copper and zinc in the livers increased during the last four weeks in the animals fed low methoxyl pectin.

Til et al. (32) fed amidated pectin (21 percent amidated) to four groups of 10 male and 10 female rats in diets containing 0, 5, 10, and 15 percent (0, 5, 10, and 15 g per kg body weight) pectin for 90 days. Hematological parameters determined on blood collected during week 12 included hemoglobin content, packed cell volume and counts of erythrocytes and total and differential leukocytes. Urine examinations, including pH, glucose, protein, occult blood, ketones and microscopic constituents were conducted on pooled samples from each group in week 13. Serum enzymes, albumin and total protein were determined on blood collected at sacrifice. Heart, kidneys, liver, spleen, brain, gonads, thymus, thyroid and adrenals of all animals were weighed and those from the control and 15 percent pectin groups were sectioned for microscopic examination. Also sectioned and examined were the following organs: lung, trachea, salivary glands, prostate, epididymis, uterus, urinary bladder, skeletal muscle, thoracic aorta, esophagus, gastrointestinal tract, pancreas, and axillary and mesenteric lymph nodes. Microscopic examination of the groups fed intermediate levels of pectin was limited to the cecum and the stomach. Growth was slightly decreased at the 15 percent level. Food efficiency and food intake were not affected at any level. Total serum protein and albumin were reduced at the 15 percent level but the other clinical biochemical parameters and urinalysis were essentially normal. Cecal weights were increased at all levels and were dose-related. There was no gross or histologic evidence of pathology except for a slight degree of hyperkeratosis of the forestomach in some animals that was seen at the 10 and 15 percent levels.
Long-term studies

Cohen et al. (33) fed groups of nine 2-month-old Sprague Dawley rats diets containing 80 percent rat chow and 20 percent (about 10 g per kg body weight) of an experimental carbohydrate including N.F. citrus pectin, sucrose and cerelose (glucose hydrate). Weight gain after six months was lower (20 percent) on the pectin diet than on the control chow diet but protein efficiency ratio was comparable for the two diets. The relative liver weights (liver weight as percent of body weight) of rats sacrificed after 18 months was slightly lower for the pectin-treated animals (3.13), than for the controls (3.60). Serum cholesterol in the treated animals at 18 months was lower (127 mg per dl) than in the controls (202 mg per dl).

Palmer et al. (34-39) reported results of a long-term study in which male Wistar rats were fed either low methoxyl pectin, pectin N.F. or cellulose at the 10 percent level in a basal diet of rat chow. The caloric content of the cellulose in the control diet was adjusted by admixture with dextrose to that of pectin which was taken as 0.62 kcal per g. The pectin N.F. contained about 59 percent ester groups; the low methoxyl pectin contained about 17 percent amide and 29 percent ester groups. For comparison of growth rates, 20 rats were fed each diet and water ad libitum. Pectin fed rats did not grow as rapidly as control rats. Food efficiency, however, was similar for all diets. Stable weights of about 540, 570, and 620 g were reached on the low methoxyl pectin, pectin N.F. and control diets, respectively. Rats from three additional groups of 64 animals each were fed the same diets and autopsied at 30, 90, 180, 300, 450, and 736 days. Comparison of organ weights (expressed as percent of body weight) at 90 and 736 days showed no significant differences (P=0.05) among the three groups in weights of liver, spleen, kidney, adrenal, thymus, heart, and testes. Findings at 30, 180, 200, and 450 days were not reported. While the studies were conducted for 736 days, necropsies and histopathological evaluations were performed only at the end of 90 days. Eight rats from each of the control and treated groups were examined. Tissue changes observed in the livers, spleens and kidneys of control and treated rats were interpreted to be reversible in nature and not to be of experimental significance owing to comparable incidence and severity. No significant differences were found in hemoglobin, hematocrit, total or differential leucocyte counts or serum cholesterol levels in rats on the three diets. During the two-year study 11 rats died of natural causes in the control groups (13 percent), 17 in the low methoxyl pectin group (20 percent) and eight in the pectin N.F. groups (10 percent).
Special studies

Keys et al. (40) fed four groups of six men two pairs of American type diets. One diet in each pair was supplemented with 15 g per day (210 mg per kg body weight) of citrus pectin N.F. The two pairs of diets differed in the source of part of the carbohydrate; in one pair a considerable amount of legume carbohydrate was isocalorically matched by sugar in the other pair. Fat supplied about 40 percent of calories in all diets: about 20 percent was from saturated fats, 18 percent from monounsaturated and 2 percent from polyunsaturated fats. The groups were fed each of the two pectin diets and their respective control diets for successive three-week periods. At the end of the dietary periods, serum cholesterol levels were 5 percent lower for those receiving the pectin diets than for the controls.

In chickens (41, 42), swine (43), and rabbits (44), it has been shown that 5 percent citrus pectin added to basal diets supplemented with cholesterol lowered serum cholesterol levels. Hypcholesterolemia occurred in weanling rats fed pectin at the 3 percent level in a semipurified or a practical diet if 1 percent cholesterol was added to the diets, but there was no effect when cholesterol was omitted from the diets (45).

No teratogenic effects were found in a study in which groups of 17 to 19 female Charles River rats were fed diets containing either 2 or 5 percent concentrations of amidated pectin during gestation days 6 through 15. Control rats were fed either 2 or 5 percent non-amidated pectin (high methoxyl pectin). Maternal body weights, body weight gains and food consumption were similar for all groups. Similar numbers of corpora lutea, implantation sites, resorption sites, and fetuses were displayed by all dams. Fetal body weights as well as external, internal and skeletal development were similar for all groups (46).

No reports were available to the Select Committee on the possible carcinogenic or mutagenic properties of pectins.

V. OPINION

Pectin is a constituent of the cell walls of all green land plants. Among food sources, fruits and vegetables have the highest content and may contain 0.5 to 4 percent of pectic substances on a fresh weight basis. Extensive studies on pectins and pectinates demonstrate that they are largely decomposed by the microflora in the colon of man and experimental animals. The breakdown products do not appear to enter metabolic pathways to an appreciable extent because pectin in the diet is not available as a source of energy. Animal feeding studies have shown no toxic effects when pectins
and pectinates, including amidated pectins, are fed at levels many times
greater than the estimated human intake of pectin added to foods.

In the light of the foregoing, the Select Committee concludes that:

There is no evidence in the available information on pectin and pectinates, including amidated
pectins, 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.
VI. REFERENCES CITED


19. Letter, dated November 22, 1976, from J.P. Frawley, Director of Toxicology, Hercules Incorporated, Wilmington, Del., to F.R. Senti, Research Associate, Federation of American Societies for Experimental Biology, Bethesda, Md.


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