CHAPTER 12
Nonfood Uses of Pectin

H.-U. Endress
Herbstreith and Fox KG
Pekton-Fabrik
Neuenburg, Germany

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I. INTRODUCTION

The numerous properties of pectin make it virtually universal in its applicability. Established uses in humans have been, for example, in blood plasma substitution, detoxication, and dietary-fiber fortification (Kertesz, 1951). Medical and nonmedical applications alike have expanded abreast of modern technology into new areas in which multifunctional substances predominate.

II. BIOCHEMISTRY AND PHYSIOLOGY

A. Medicine and Health

Pectin appears to exercise its beneficial effects on humans by its action on cholesterol absorption, on the exocrine pancreatic hormones and enzymes, on the ileo-hepatic and the ceca-hepatic circulation, on colon transit time, and through its intestinal microbial degradation products. Colon transit times have implications for tumorigenesis (Ink and Hurt, 1987). The action of the pectic
substances, in some cases, may depend on the chemistry of galacturonic acid (Suzuki and Kajuu, 1983).

Recent benefits from applications of pectin in medicine include its effect on blood cholesterol reduction, manufacture of pharmaceuticals, salves, and emollients, etc. Pectin has been reported to have antiviral activity (Bender, 1969).

1. Hemostasis

Pectic substances are often a component in hemostatic formulations (Deuel, 1945; Kertesz, 1951; Tomic, 1981; Raskai and Szijjarto, 1984, 1985; Thiele, 1987b). Their contribution is apparently a function of the galacturonic acid, the blood concentration of which governs coagulation time (Bock et al., 1964). A lyophilized sponge containing pectin (10–50%) is a medically useful hemostatic device (Lavia et al., 1981). Sulfated degradation products of pectin are potent anticoagulants (Alburn and Seifert, 1956). Pulver (1961) formulated a synergistic anticoagulant composition of heparin and the polysulfuric acid ester of oxidatively degraded pectin. In the three-stage wound-treatment procedure of Alvarez (1989), 35–50% pectin is applied in the first stage and 5–10% pectin, in the second stage. Freeman and Pawelchak (1985) developed an occlusive, multilayered wound dressing containing a water-dispersible hydrocolloid, e.g., pectin (45–65%). For this purpose, the pectin particle size should be 10–40 mesh (Freeman and Pawelchak, 1988).

For burns and other wounds, Nambu (1985) composed a water-insoluble gel from polyvinyl alcohol and 2% pectin, and freeze-dried it to 95% soluble solids content. Wound dressings made of polyurethane foams, 5–50% pectin and/or other water dispersible hydrocolloids (Cilento and Freeman 1988a,b) have been patented, as well as an air-permeable, deodorizing, multilayer bandage for special open-skin disorders (Mathews and Steer, 1980). Cilento et al. (1984) developed a microporous adhesive tape for surgical purposes, in which a rubber material and a hydrocolloid, e.g., pectin (20–65%), composed the adhesive layer.

After some kinds of surgery, prosthetic devices must be sealed in the stoma. Sealants for this purpose may include pectin (Cilento et al., 1979; Chen et al., 1980 a,b, 1981, 1987; Larsen and Sorensen, 1980; Doehnert and Hill, 1985).

2. Cholesterol

A significant reduction of blood cholesterol was reported in studies with a wide variety of subjects and experimental conditions (Keys et al., 1961; Palmer and Dixon, 1966; Durrington et al., 1976; Jenkins et al., 1976 a; Kay and Truswell, 1977; Mietinen and Tarpila, 1977; Kay et al., 1978 Jenkins et al., 1979; Ginter et al., 1979; Stasse-Wolthuis et al., 1980; Nakamura et al., 1982; Schwandt et
al., 1982; Judd and Truswell, 1982; Challen et al., 1983; Hundhammer and Marshall, 1983; Schuderer, 1986). At least 6–15 g/day seems to be necessary. Blood-cholesterol reduction was almost nonsignificant, when less than 6 g/day was consumed (Palmer and Dixon, 1966; Raymond et al., 1977; Delbarre et al., 1977). Better results were obtained if pectin was completely hydrated in a food product compared to powdered pectin mixed with food (Behall and Reiser, 1986). The cholesterol-lowering effect was proportional to the amount of dietary cholesterol in the blood (Ullrich, 1987). In two studies, pectin had no influence on blood cholesterol (Fahrenbach et al., 1965; Hillman et al., 1985). In the study by Miettinnen and Tarpila (1977), serum cholesterol was reduced by 13% within 2 weeks. In a long-term study, they further lowered blood cholesterol by 15%.

Cerda et al. (1988) observed, from patients at risk of coronary heart disease, that pectin supplementation decreased blood cholesterol by 7.6%, concluding that a pectin-supplemented diet can significantly reduce blood cholesterol without a change in lifestyle.

In the study of Schwandt et al. (1982), pectin was applied in combination with cholestyramine, a bile-acid sequestrant, and it was shown that pectin augmented the reduction of cholesterol by 20%, compared to cholestyramine alone.

Apparently, the degree of esterification (DE) of pectin has no influence on the cholesterol-lowering effect of pectin. Using 15 g high-methoxyl (DE 71%), low-methoxyl (DE 37%), and amidated pectins, Judd and Truswell (1982) obtained similar results from each in reducing serum cholesterol. These results could not be confirmed by Miettinnen and Tarpila (1977). They found no effect on serum cholesterol in hypercholesterolemic patients who consumed 6 g/day low-methoxyl citrus pectin. According to Schuderer (1986), only high-methoxyl pectins have a cholesterol-lowering effect, but in studies with rats, Ershoff and Wells (1962) showed that pectins with an approximately 10% methoxyl content counteracted the increment of rat-liver cholesterol induced by cholesterol feeding, whereas pectic substances with approximately 5% methoxyl content were ineffective.

Pectic substances are involved in bile-acid metabolism (Eastwood et al., 1980). An addition of 15 g pectin to the meal of ileostomy patients increased bile-acid excretion by 35% and net cholesterol excretion by 14% (Bosaeus et al., 1986). The increased bile-acid excretion seemed to be independent of the DE of the pectins (Pfeffer et al., 1981; Judd and Truswell, 1982). Pectic substances not only accelerated the bile-acid excretion, but they also changed the bile-acid profile.

A 15 g pectin/day diet in man increased fecal excretion of neutral steroids by 17%, of bile acids by 35% (Kay and Truswell, 1977) and of acid steroids by 11% (Ross and Leklem, 1981). A pectin-fortified regimen increased neutral steroids excretion, observed for male but not for female humans (Stasse-Wolthuis et al., 1980).

Pectin degradation products are claimed to have an influence on blood
cholesterol. While pectin cannot be digested by human enzymes, the colon microflora produce deesterifying and depolymerizing enzymes.

3. Lipids

Ershoff and Wells (1962) showed that pectin counteracted the increment of liver total lipids in rats. At an intake rate of 2 to 50 g/day, pectic substances reduced liver and blood lipids, low-density (LD) and/or very low density (VLD) lipoprotein (L), and the LDL:HDL ratio. High-density lipoprotein (HDL) is only little affected by pectin. Cerda et al. (1988) also observed that pectin supplementation decreased LDL by 10.8%, and the LDL:HDL ratio by 9.8%. The other plasma–lipid fractions showed no significant change. Richter et al. (1981), Nakamura et al. (1982), and Schwandt et al. (1982) showed that 18 g, 9 g, and 12 g pectin per day reduced LDL and VLDL by 5, 11, and 35%, respectively. HDL was increased by 4% (Richter et al., 1981).

Pectin forms complexes with LDL in the gut and so hinder LDL absorption. The results of Baig and Cerda (1981) indicate that the interaction is of an electrostatic nature, and perhaps hydrogen bonding. Falk and Nagyvary (1982) found that one part of high-methoxyl pectin bound 4 parts of LDL. Low-methoxyl pectins bound less LDL, meaning that the binding mechanism depended on the DE of the pectic substances. Pectin consistently failed to reduce the level of blood triglycerides (Reiser, 1987).

4. Enzymes and Hormones

Schuderer (1986) discussed the possibility of the influence of pectin on some exocrine pancreatic hormones. Morgan et al. (1979) and Levitt et al. (1980) reported that a pectin supplement reduced the production of gastric inhibitory polypeptide. This hormone reduces gastric motility and insulin secretion, which could result in a lowered activity of the enzyme, α-hydroxy-α-methylglutaryl-(HMG) CoA-reductase, because its activity depends on the insulin concentration. Serum cholesterol can also be reduced, because HMG-CoA-reductase is involved in an early step of the endogenous cholesterol synthesis.

There are two possibilities by which pectic substances might have an influence on exocrine pancreatic enzymes. Pectic substances are able to increase the viscosity of the stomach contents and prohibit contact between food components and digestion enzymes. They can also reduce the enzymes’ activities by forming complexes with them (Schuderer 1986).

Isaksson (1982), Isaksson et al. (1982 a,b, 1984), Dutta and Hlasko (1985) reported a reduction of amylase activity by 10 to 40%, of lipase activity by 40
to 80%, and of trypsin activity by 15 to 80%, caused by pectin. This effect was accompanied by an increase in viscosity of the digestion fluids.

Cummings et al. (1979) reported a significantly greater excretion of fatty acids (80%) and bile acids (35%), compared to a control period, when healthy volunteers consumed 36 g/day of pectin.

5. Glucose Metabolism

Several studies with insulin-dependent and insulin-nondependent diabetics have shown that pectic substances lower blood glucose and insulin levels after a carbohydrate meal (Jenkins et al., 1976b; Monnier et al., 1978; Vaaler et al., 1980; Poynard et al., 1980; Williams et al., 1980; Kanter et al., 1980; Levitt et al., 1980; Tunali et al., 1990). The response was comparable in studies with healthy volunteers (Jenkins et al., 1977, 1978; Holt et al., 1979; Gold et al., 1980; Kanter et al., 1980; Sahi et al., 1985; Sandhu et al., 1987).

6. Weight Reduction

Pectin is thought to immobilize food components in the intestines, thereby reducing the rate of digestion (Hansen and Schulz, 1983). The result is that food absorption is concomitantly lessened. Flourie et al. (1984) found that with increasing pectin dosages, the absorption of food components from the stomach was reduced. This reduction was also correlated with the size of the jejunal unstirred water layer, which increases in thickness as a result of consuming pectin (Gerencser et al., 1984).

The thickness of the layer is said to have an influence on absorption by prohibiting contact between the intestinal enzymes and the food, thus reducing the latter’s availability (Gatfield and Stute, 1972; Wilson and Dietschy, 1974; Dunai and Schneemann, 1981; Hansen an Schulz, 1983).

Pectin, a hydrocolloid, is able to bind a large volume of water that, in the process, bestows a feeling of satiety. The effect is again to reduce food consumption. Experiments showed a prolongation of the gastric-emptying half-time from 23 to 50 min, of a meal fortified with pectin (Holt et al., 1979). The gastric-emptying half-time was doubled by the intake of 20 g apple pectin per day for 4 weeks (Schwartz et al., 1983, 1988). Inasmuch as pectin delays gastric emptying and confers a feeling of satiety in obese subjects, it may be a useful adjuvant in the treatment of disorders related to overeating (Di Lorenzo et al., 1988). Formulas containing apple pectin mixed with insoluble dietary fiber, certain enzymes, and proteins are sold for this purpose.

Schneemann (1985) stated that “food intake is decreased by the concurrent intake of nonnutrients”. Pectin is a nonnutrient.
7. Medicaments and Pharmaceuticals

The ability of pectin to delay the absorption of drugs (Kertesz 1951) was taken advantage of in the manufacturing of encapsulated pharmaceuticals (Wuhrmann, 1939; Murray and Finland, 1946; Welch et al., 1947; Welch, 1950; Gyarmati et al., 1980; Asano et al., 1984; Ogawa et al., 1987a,b; Salatinjants, 1987; Washington et al., 1988).

Problems with the solubility and absorption of nonuniform procaine and penicillin crystals led Sumner and Grenfell (1955) to discover that their precipitation in the presence of pectin resulted in greater uniformity of shape and size. Corticotropin, used to treat rheumatism and arthritis, suffers the disadvantage of having to be frequently injected, in order to maintain a continuous therapeutic effect. To circumvent this problem, a complex with pectic acid or other polybasic acids was formed (Murphy et al., 1963). The ability of pectinic and pectic acids to form sodium, potassium, calcium, and magnesium salts is of medical benefit, when prescribing remedies that contain immunologically active substances requiring slow release (Mill et al., 1967).

Salts of pectinic acids improve the solubility of some drugs (Becher and Leya, 1946; Owens and Maclay, 1951). Welch (1952) formulated a pectin-coated penicillin salt that increased and prolonged blood levels of penicillin. Pectin particles stabilize penicillin preparations (Welch, 1950), 1-(p-nitrophenyl-sulfonamido)-thiazole retention enemas (Hoehn, 1950), and X-ray compositions (Slaybaugh, 1953). Pectin and mixtures of pectin with compatible substances have performed as drug carriers (Sackler and Sackler, 1967; Hiroshi et al., 1987).

Negrevergne (1969, 1974a,b) described the advantages of a novel pyrazolidone–pectin derivative in which the pectin molecule is bound to the number 4 position of 3,5-dioxo-1,2-diphenyl-4-N-butylpyrazolidine. This derivative is an antiinflammatory substance. Pectin in demulcents helps to alleviate gastrointestinal distress (Bender, 1969; Hill, 1976). It is a carrier of interferon (Chany et al., 1975, 1977). Aqueous dispersions (0.1–5%) are used to prepare microcrystalline beads of vitamin A acetate by wet-milling (Keller and Klaeni, 1981). Calcium salts of polygalacturonic acid are a remedy for hyperphosphatemia (Kulbe and Weber, 1984). Encapsulation of sulfamerazine was accomplished by coacervation with pectin and gelatin (McMullen et al., 1984). Bates (1989) patented a decongestant composed of vegetable oil, aloe vera, zinc, vitamins, and pectin.

For treating diarrhea (Malyoth, 1934), pectin and combination preparations of pectin with other substances like agar (Tompkins, 1938), tannic substances (Mansfield, 1940), iodine (Otto, 1941), kaolin (Kaopectate, Upjohn), kaolin, bentonite, neomycin (Bennett, 1958), bentonite and alkyl polyalcohol (Jensen, 1969), aluminum phosphate (Raudnitz, 1979), medical activated charcoal (Thiele, 1987a) or mixtures with charcoal, kaolin (bolus alba) and sweet whey (Laves,
1979) have been invented. Nickel–pectinate (Myers, 1941) and the combination pectin and tomato pulp were also produced.

Pectin also abolishes or alleviates the symptoms of dumping in patients suffering from dumping syndrome, because of its viscous nature (Leeds et al., 1977, Lawaetz et al., 1983). By increasing the viscosity of a meal, gastric emptying is reduced significantly. Zimmalo et al. (1989) showed that liquid stool induced by isotonic tube-feeding formula is reversed by pectin.

**B. Heavy-Metal Toxicity**

Since the first reports that pectin was a good antidote for heavy-metal poisoning (Kertesz, 1951), it has been discovered that the absorption of strontium into the bone structure of rats can be suppressed by pectin (McDonald et al., 1952; Rubanovskaya, 1960; Patrick, 1967). The gastrointestinal tissue of rats fed a diet containing pectin was found to contain only 0.1% of strontium -90 in the diet. The binding of strontium in vivo is less effective of acidic than at alkaline pH (Bessubov and Hatina, 1960). Waldron-Edward et al. (1965) did not detect any strontium in the blood, 24 hr after their subjects ingested pectin; strontium concentration in the skeleton was significantly lower, when compared to that from a pectin-free diet.

The affinity of pectin for metals is, as follows: Mg < Mn < Cr < Hg < Fe < Ni < Co < Cu < Zn < Sr < Cd < Ba < Pb (Paskins-Hurlburt et al., 1977). Pectin has been evaluated as a prophylactic against lead toxicosis (Bondarev et al., 1978). Pectic substances form insoluble pectinates in vivo that are excreted in the stool and urine (Bessubov and Khatina, 1960; Nicolescu et al., 1968; Markova et al., 1976; Paskins-Hurlburt et al., 1977; Stantschev et al., 1979). Typical symptoms of lead poisoning disappeared when some factory workers ate 8–9 g of pectin per day (Stantschev et al. 1979).

Following the Chernobyl nuclear disaster, Ukrainians were fed pectin-enriched foodstuffs, in order to take advantage of the complexing ability of pectin with radioactive nuclides.

**C. Mutagenicity**

There was a significant reduction of nitro-compounds when Rowland et al. (1983) fed rats a diet fortified with pectin. Jongen et al. (1987) reported that pectin inhibited in vitro mutagenicity by fava beans treated with nitrite. The inhibition was accompanied by a diminished N-nitroso content.
III. DENTISTRY

The first toothpaste containing pectin was patented in 1932 (Deutsche Pektin- 
gesellschaft 1932a). Since then, dental impression materials having improved 
shelf-life in the dry state have been formulated to contain pectin, along with 
other reactive substances (Lochridge, 1951; Noyes and Lochridge, 1953a,b,c; 
Rabchuk, 1957, 1959). Pectin and pectinates are suitable polyanionic materials 
for making dental adhesives (Bohne, 1942; Gidwani et al., 1974, 1975a,b; 
Keegan et al., 1975; Beachner, 1968). A barrier of pectin was designed in a 
dry toothpaste to protect a bicarbonate and a peroxide from premature wetting 
(Bohm et al., 1989).

IV. OTHER PRODUCTS

A. Skin-Care Products

Contemporary recommendations for pectin include shaving (Deutsche Pektin- 
gesellschaft, 1932b) and skin lotions (Kröper, 1934; Anonymous, 1935; Bates, 
1987), soaps (Kertesz, 1951), hair pomades (Lesser, 1939; Rae, 1944), excipi- 
ents (Toni, 1946), emollients (Okuyama et al., 1981), and deodorants (Holzner, 
1989). For treating acne vulgaris, Ciesla et al. (1982) patented an aqueous gel 
containing 1–3% pectin, salicylic acid, and/or benzoylperoxide.

B. Cigarette Manufacture

In the tobacco industry, pectic substances are used to make self-extinguishing 
cigarettes (Simon, 1984), as a binder for reconstituted tobacco sheets and films 
(Hind and Seligman, 1968a,b, 1969; Hind and Hopkins, 1968, 1978; Hind, 
1970; Deszyck, 1973 Anonymous, 1977; Perkins and Bale 1979; Ohashi et al., 
1986), as a humectant (Georgiev, 1979), in tobacco substitutes (Hind and Hop-
kins, 1968; Anonymous, 1971; Hedge, 1972; Hind and Kelly, 1972; Deszyck, 
1974; Perkins and Bale, 1979), in wrappers (Anonymous, 1977; Hind and Hop-
kins, 1978) and in flavors (Nichols et al. 1987; Denier et al., 1989; Tateno and 
Masuko, 1989).

C. Microbiological Culture Media

It is possible to identify pectolytic enzyme activity by the transparent zones 
created around colonies of enzyme-producing microorganisms growing in pectin-

The production of a highly potent interferon is enhanced on culture media by inclusion of polyanions, e.g. pectin, in the medium (Iizuka et al., 1984).

D. Soil Conservation

Van Leuven (1967) used the binding power of pectin (0.05–7.5%, dry mass) in a mixture to prevent soil erosion on newly planted areas, an application accommodated by soil calcium (Hirsbrunner, 1988).

In a related application, an aqueous pectin dispersion was injected into reservoirs constructed with highly permeable earth, and when the pectin came in contact with brine containing divalent cations, it precipitated and effectively sealed the pores (Christopher and Clauset, 1980).

E. Feeding Animals

Sawadogo et al. (1988) discovered that pectin as well as oligo-galacturonic acid in the ration stimulated blood prolactin and growth hormone secretion in ewes. During the growth period of pigs, a 2% pectin addition to the feed caused a decrease in weight gain. During the finishing period it resulted in an increase, but did not affect the feed-conversion rate. Pectin decreases the back-fat thickness of pigs (Lagreca and Marotta, 1985). Some pellets for marine fish feeding are coated with pectin (Cox, 1985).

F. Miscellaneous Uses

Given the multifunctionality of pectin, it has been viewed, not surprisingly, as an industrial chemical and as an intermediate in chemical synthesis. Insecticides (Baier, 1940; Wilson, 1940) including plant virucides (Kasugai et al., 1975) and a plant antifreeze (Woods, 1988) have been formulated with pectin.

In the enzymatic synthesis of dehydrogalacturonosylgalacturonates, pectin is the substrate (Bock et al., 1987). It has been put in some therapeutic gels (Raudnitz, 1979), sanitary napkins (De Merre, 1967), and contraceptives (Gero, 1987a,b). More recently, Kasten (1989) invented biodegradable drinking straws in which coloring and flavoring substances in a pectin layer are released when liquid passes through the straw. Sausage coatings are made from gelatin and
pectin (Childs, 1957; Julius, 1967). In various other ways, pectic substances have been involved in the manufacture of sausage coatings, as, for example, in dewatering baths in collagen extrusion (Higgins, 1979) and edible casings with water-resistant printing ink (Winkler, 1973).

Fruit juice decolorization is facilitated by activated carbon coated by calcium pectate (Wilson, 1956). A 1% potassium pectate solution has performed as a fining agent (Baker, 1976; Strohm et al., 1987) without appreciably changing juice composition (Wucherpffennig et al., 1988). This pectate increased by 50% the ultrafiltration flux rate of a continuous process for apple-juice making (Endress, 1988; Wucherpffennig, 1990). In berry juice, no color was removed (Baumann, 1989). In wineries, the removal of copper, iron, and lead from musts and wines has been attempted (Schlemmer, 1986).

Pectic substances have been assigned an important role in making paper substitutes (Schoeppe, 1979), carbonless copy paper (Matsukawa and Saeki, 1975, 1976; Matsukawa et al., 1976; Sankar and Arun, 1989) photographic films (Land, 1956; Salminen and Weyerts, 1961; Schmidt et al., 1962), lead storage batteries (Beste et al., 1966; Ryhiner et al., 1967a), homeoporous electrodes (Ryhiner, 1967b), ceramics (Ruben, 1988), porous silicates (Robinson, 1988), gas filters (Moroni and Kalbow, 1978), foams (Kennedy, 1985) including flame-extinguishing foams (Chiesa, 1973; Hiltz et al., 1987; Pless and Ullmann, 1990), catalytic silver (Ramirez et al., 1975), rust removers (Reghin et al., 1951), lubricants (Morway and Mikeska, 1954; Lanini et al., 1989) and, finally, in plasticizers (Fetzer and von Rex, 1986).

References


