

agents markedly influence Kupffer cell phagocytosis(17).

Another possible mechanism for the heparin effect is related to its interaction with an opsonic system involving gelatin stabilized colloids(18-20). Thus, heparin may react with gelatin directly or promote the interaction of plasma opsonin with the gelatin stabilized colloid. Since heparin is essential for the agglutination of colloid gold *in vitro*(19), it would seem that a direct effect of heparin on the opsonin-particle interaction is plausible.

The finding that other sulfated polysaccharides do not mimic the action of heparin on phagocytosis suggests the mechanism of heparin action involves some degree of specificity and is not merely due to the high density charge of a sulfated polysaccharide. Since heparin is an ubiquitous constituent of connective tissue elements, it is probably available in the phagocytic environment and may, indeed, serve an important role in the particle preparatory phase of phagocytosis due to its potential ability to promote opsonization.

*Summary.* Colloidal gold phagocytosis by rat liver slices was slight in oxalated rat plasma or serum; however, heparin addition markedly increased the uptake. Heparin also augmented the hepatic phagocytosis of human serum albumin aggregates from oxalated plasma. Other sulfated polysaccharides either had no effect, or only slightly enhanced, gold uptake. The mechanism of heparin action in promoting phagocytosis may be related to

facilitation of opsonin-particle interaction.

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Received March 2, 1966. P.S.E.B.M., 1966, v122.

### Anti-Hypercholesterolemic Action of Scleroglucan and Pectin in Chickens.\* (31188)

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Pectin has been shown to reduce hypercholesterolemia in cholesterol-fed rats(1), and in chickens, rabbits, and man(2). Although a number of other roughages or bulk-

\* Paper of the Journal Series, N. J. Agri. Exp. Station, New Brunswick.

forming materials tested by Wells and Ershoff showed no such activity(1), they later described inhibition of hypercholesterolemia by feeding certain gums and carrageenan(3).

The present report describes the strong anti-hypercholesterolemic activity of sclero-

TABLE I. Body Weights, Efficiency of Feed Utilization, Plasma Cholesterol, and Composition of Excreta of Growing Chicks Fed Anti-Hypercholesterolemic Agents.

Dietary supplement	Avg body wt, g	Feed efficiency*	Plasma cholesterol, mg %	Composition of dried excreta		
				Lipids	Cholesterol	Protein (N×6.25)
%						
Exp I						
Cellulose (control)	262 ± 13†	.47	293 ± 11	4.30	.44	
Citrus pectin, N.F., 3%	222 ± 12‡	.37	214 ± 11§	10.22	.71	
Scleroglucan, ¶ 3%	198 ± 11	.39	178 ± 21§	9.46	.74	
Exp II						
Cellulose (control)	289 ± 10	.62	267 ± 9	5.85	.57	50.25
Citrus pectin, N.F., 2%	301 ± 6	.56	206 ± 8§	9.24	1.01	49.50
Scleroglucan, ¶ 2%	242 ± 10	.50	183 ± 9§	8.99	1.10	48.19

\* Grams of weight gain per g of feed during 4-wk period in Exp I and during 2-wk period in Exp II.

† Arithmetic mean ± S.E.

‡ Significantly different from control value ( $P < .05$ ).

§ Significantly different from control value ( $P < .001$ ).

|| Significantly different from control value ( $P < .01$ ).

¶ Polytetran, manufactured by Pillsbury Co., Minneapolis, Minn.

glucan,† a new polysaccharide with certain physical characteristics similar to those of pectin, and the changes in lipid excretion mediated by this material, which are suggestive of its mode of action.

**Materials and methods.** Day-old male chicks in groups of 10 or 12 were fed *ad lib* a hypercholesterolemic diet containing 25% whole egg powder, 25% soybean oil meal, 3% cellulose, 2% dicalcium phosphate, 1% limestone with trace minerals, 0.5% NaCl, 0.4% vitamin mixture, and glucose monohydrate (cerelose) to 100%. The diet contained 23.2% protein, 12.7% fat, and 0.65% cholesterol, the last two supplied to a large extent by the egg powder. The experimental variables (cellulose, pectin, or scleroglucan) replaced equal amounts, by weight, of glucose monohydrate. The chicks, kept in electrically heated battery brooders on raised wire floors, were bled by heart puncture at 3 weeks of age for plasma cholesterol determinations(4). During the fourth week all excreta were collected for a 2-day period in one experiment, and for three 2-day periods in the other. The excreta were dried at 80°C to constant

weight; total lipids were determined gravimetrically after extraction with chloroform:methanol (2:1), and cholesterol was determined on an aliquot of the lipid extract by the method of Zlatkis(5). In one of the experiments, nitrogen in the dried excreta was also determined, using a semi-micro-Kjeldahl method.

**Results and discussion.** Compared with the cellulose (control) lots, scleroglucan reduced weight gains of chicks in both experiments, while pectin did so only when fed at the 3% level (Table I). Plasma cholesterol in the scleroglucan- and pectin-fed birds was significantly reduced in both trials below that of the controls, though the reduction was somewhat greater at the 3% level of supplementation. The values were lower for the scleroglucan-fed birds than for the pectin-fed ones, but the differences between these two treatments were not significant at the 5% level of probability in either of these 2 trials. The reduced plasma cholesterol levels were accompanied by marked increases in the level of excretion of total lipid and cholesterol, but not of greater protein (nitrogen) excretion (Table II). There is, of course, a basic difference between the excretion of lipids and that of nitrogen-containing compounds, in particular protein, inasmuch as nitrogen will ultimately be excreted in the urine even if protein is absorbed and metabolized. In the

† Polytetran, kindly supplied by Pillsbury Co., Minneapolis, Minn., is a refined grade of scleroglucan. Scleroglucan is a linear chain of glucose molecules linked beta 1-3, with side branches of single glucose molecules linked beta 1-6 to every third glucose unit in the chain(8).

TABLE II. Excretion of Dry Matter, Total Lipids, Cholesterol, and Protein as Percent of Amount Ingested (Exp II).

Dietary supplement	Feed ingested,* g/day	Excretion as % of ingested†			
		Dry matter	Total lipids	Cholesterol	Protein
Cellulose (control)	26.8	27.0	11.1	21.3	52.4
Citrus pectin, N.F., 2%	30.6	28.4	19.9	39.5	54.0
Scleroglucan, ‡ 2%	24.2	26.6	16.8	40.6	49.6

\* Averages for entire collection period, for feed consumed by the whole group.

† Averages for three 2-day collection periods, for excreta of the whole group.

‡ See Table I, footnote ¶.

mixed excreta of the chicken (urine and feces) the larger fecal excretion of nitrogen might have been balanced by a smaller urinary excretion of nitrogenous endproducts of metabolism, if less protein were to have been absorbed from the diets supplemented with pectin or scleroglucan. Considering, however, that the ratios of dry excreta to ingested feed were very nearly equal for the 3 groups (Table II), it may be assumed that there was no major difference in protein utilization.

The feeding of pectin to adult chickens, in the absence of dietary cholesterol, over a prolonged period, did not reduce plasma cholesterol levels, even though atherogenesis was reduced(6). In a separate short-term experiment pectin feeding also did not affect plasma cholesterol, even though cholesterol excretion was increased.‡ The mode of action of pectin under those circumstances may, however, still have been similar to that existing in a dietary hypercholesterolemia, namely, an increased excretion of—in this case endogenous—cholesterol, thus reducing cholesterol deposition in the blood vessels. On the other hand, the increased cholesterol excretion in pectin-fed normocholesterolemic birds may be incidental, and the anti-atherogenic properties of pectin may revolve around the reduced caloric intake, as a result of decreased fat absorption. A reduced food intake has been previously shown to reduce atherogenesis(7).

Although the chemistry of scleroglucan is

entirely different from that of pectin, the two materials have certain physical characteristics in common. This suggests that their anti-hypercholesterolemic action is related to their physical rather than to their chemical properties.

*Summary.* Pectin and the polysaccharide scleroglucan reduced dietary hypercholesterolemia in chicks; this reduction was accompanied by an increased excretion of chloroform-methanol extractable lipid, including cholesterol. The chemical dissimilarity of pectin and scleroglucan suggests that the anti-hypercholesterolemic activity of the two materials may be due to their physical rather than to their chemical properties.

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‡ Unpublished data.

Received March 3, 1966. P.S.E.B.M., 1966, v122.