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SEPARATION OF THE LIGNOCELLULOSE OF NON-WOODY PLANTS INTO ITS MAIN COMPONENTS AND STUDY OF THEIR PROPERTIES. II. HEMICELLULOSES

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Hemicellulose fractions possessing biological activity have been isolated from the lignocellulose of nonwoody plants (kenaf tow, cotton stems) by alkaline extraction.

Continuing a study of processes for separating lignocellulosic material into its main components [1], we have conducted the alkaline extraction of ground flour, preextracted with alcohol–benzene, from the stems of the cotton plant and from kenaf tow with the aim of isolating hemicelluloses and studying their properties.

It is known that in some cases the hemicelluloses of annual plants can be isolated without preliminary delignification [2]. Direct alkaline extraction has some advantage: the elimination of delignifying agents the use of which frequently leads to a change in the physical and chemical properties of the polysaccharides and to the loss of certain amounts of carbohydrates.

We isolated the hemicelluloses from cotton stems and kenaf tow by extraction with 0.5-10% NaOH. The results showed that with an increase in the concentration of alkali the yield of hemicelluloses rose (Table 1), while their amount in the kenaf tow was almost twice that in the cotton stems. A fall in the level of Komarov lignin in the samples investigated is explained by its partial solubility in solutions of alkali. Paper chromatography of hydrolysates of the hemicellulose fractions revealed the presence of monosaccharides – glucose, xylose, arabinose, rhamnose, galactose, and uronic acids. The IR spectra of the samples investigated had absorption bands characteristic for the polysaccharides of hemicelluloses.

It is known that hemicelluloses (HCs) are added to food products because of their capacity for expelling cholesterol from the organism [3-6]. This process takes place either as a result of the sorption of cholesterol in the lumen of the intestine or by interference in the metabolism of this steroid. The main route for the elimination of cholesterol from the organism is excretion as a component of bile and, accordingly, subsequent evacuation into the intestine and then to the exterior [5]. Following this assumption, we planned to investigate the biological activity of the HCs of cotton stems and kenaf tow.

Experiments on rats showed that, on oral administration to the animals for six days in a dose of 50 mg/kg, the HCs of cotton stems (sample 1) and of kenaf tow (sample 2) caused falls in the level of blood serum cholesterol by 44.0 and 38.5%, respectively. The other HC samples, extracted by more concentrated alkali, exhibited a less pronounced effect. However, we must mention the unidirectional nature of the effect studied, i.e., the possession of a hypocholesteremic action by all the HC samples (Table 2). A study of the interrelationship of the effect found and the process of bile elimination showed that, on oral administration to the animals for six days, the HCs most active in the hypocholesteremic respect (sample 1 from cotton stems and sample 2 from kenaf tow) raised the physiological level of bile secretion by 23.8 and 12.0%, respectively (see Table 2). The other samples of HCs also exhibited bile-stimulating activity but showed only a weak hypocholesteremic activity. It is obvious that the mechanism of the hypocholesteremic action of these compounds is somewhat different from that of sample 1 of the HCs of cotton stems and sample 2 of the HCs of kenaf tow.

To judge degrees of sorption activity, we used a model of the hypersecretion of bile evoked by a powerful choleretic – cholic acid, the chemical structure of which is based on the cholesterol skeleton. On its entry into the organism of experi-

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TABLE 1. Levels of Hemicelluloses and Lignin in the Lignocellulose Raw Material

Sample	NaOH concentration, %	Yield of hemicellulose, %	Amount of Komarov lignin in the residue, %
Cotton stems sample 1	0.5	4.4	28.1
" 2	1.5	8.4	26.3
" 3	5.0	10.0	25.5
" 4	10.0	15.0	23.2
Kenaf tow sample 1	0.5	1.4	17.8
" 2	1.5	14.8	15.0
" 3	5.0	25.2	13.0
" 4	10.0	28.5	12.4

TABLE 2. Influence of Hemicelluloses of Nonwoody Plants on the Level of Blood Serum Cholesterol and the Secretion of Bile in Intact Animals and Under Conditions of Hypersecretion Evoked by Cholic Acid ($M \pm m$, n = 5-6)

Experimental conditions, type of HCs	Cholesterol level, mg-%	Effect, %	Volume of bile, mg/100 g in 4 h	Effect, %	HCs + cholic acid	
					volume of bile, mg/100 g in 4 h	effect, %
Intact animals	148.0±7.9	100	792.0±61.0	100	802.5±72.4	–
Control (cholic acid)					1179.6±81.0	100
Cotton stem HCs sample 1	82.5±6.1*	-44.0	980.5±52.0*	123.8	1002.6±60.5	-15
" 2	106.0±8.4*	-20.7	901.2±79.3	113.8	–	–
" 3	128.7±9.1	-13.9	752.4±58.6	-5.0	955.4±54.2**	-19.0
" 4	132.0±7.4	-10.0	1013.7±73.4*	128.0	1238.5±90.7	105.0
Kenaf tow, sample 1	126.0±7.0	-14.8	–	–	–	–
" 2	91.0±5.8*	-38.5	871.2±62.0	112.0	943.6±57.2**	-20
" 3	91.0±6.4	-12.0	958.3±78.5	121.0	1321.1±88.2	112.0
" 4	110.0±4.9*	-25.6	974.1±49.4*	123.0	1450.3±90.2**	120

*Significant at $P < 0.05$ in comparison with intact animals.
**Significant at $P < 0.05$ in comparison with the controls.

mental animals and suction from the intestine, cholic acid caused an almost 1.5-fold increase in the volume of bile as compared with intact animals (Table 2). No similar enhancement of bile secretion was observed in a group of animals that received cotton stem HCs (sample 1) and kenaf tow HCs (sample 2). The effect of inhibiting hypersecretion amounted to 15.0 and 20.0%, respectively. An analogous action was exhibited by the cotton stem HCs of sample 3 (20%). The other HC samples exhibited no sorption action, which shows a difference in the mechanisms of the actions of HCs obtained by extraction with NaOH solutions having different concentrations.

Thus, it has been established that, on the whole, HCs of nonwoody plants exhibit hypocholesteremic activity. The degree of expression of this activity depends on the method of isolation. Thus, HCs isolated by weaker solutions of alkali (0.5-1.5%) exhibit a higher (38.5-44.0%) hypocholesteremic activity. The isolation of HCs by more highly concentrated solutions of alkali (5-10%) leads to a fall in the hypocholesteremic effect and, probably, to a change in the mechanism of lowering the level of blood serum cholesterol. Cotton stem HCs (sample 1) and kenaf tow HCs (sample 2) exhibit sorption activity in relation to steroid compounds – in particular, cholic acid.

EXPERIMENTAL

The hemicelluloses of the lignocellulosic material were isolated by extraction with alkali at various concentrations (0.5, 1.0, 5.0, and 10.0%). A 25.0 g sample of the raw material was extracted with 250.0 ml of NaOH, and the mixture was left

for 16-18 h, and it was then filtered and the filtrate was dialyzed against water and lyophilized. The dry residue was washed with water to neutrality of the wash waters and was kept for further analyses. The content of Komarov lignin was determined by a standard method [8].

IR spectra of the HC samples were taken on a Fourier IR spectrometer, model 2000 (Sweden). Acid hydrolysis of the hemicellulose fractions was conducted as in [9]. For paper chromatography, we used FN-12 paper and the butanol–pyridine–water (6:4:3) system, with acid aniline phthalate as the revealing agent.

The biological experiments were performed on 150 male rats weighing 220-250 g, with 5-6 animals in each group. The action of the HCs on the level of cholesterol in the blood serum and the level of bile secretion were determined after the oral administration of the HCs under investigation to the animals in a dose of 50 mg/kg for six days. During this period, the intact animals received an equal dose of water. The blood serum cholesterol content was determined by the method of L. L. Abell et al. (1952) [6], and the level of bile secretion as described in [11]. Sorption activity was determined after the oral administration of the HCs and cholic acid in a dose of 300 mg/kg for two successive days before the determination of the level of bile secretion. The results obtained were treated statistically by Student's parametric criterion on an Elektronik MK-52 microcomputer by A. E. Franchuk's program (1987).

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