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CENTRAL INTELLIGENCE AGENCY  
INFORMATION FROM  
FOREIGN DOCUMENTS OR RADIO BROADCASTS

REPORT [ ]  
CD NO. [ ]

50X1-HUM

COUNTRY USSR  
SUBJECT Scientific - Rubber  
HOW PUBLISHED Monthly periodicals; book  
WHERE PUBLISHED USSR  
DATE PUBLISHED 1944 - 1949  
LANGUAGE Russian

DATE OF INFORMATION 1944 - 1949  
DATE DIST. 2 OCT 1950  
NO. OF PAGES 20  
SUPPLEMENT TO REPORT NO.

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SOURCE Periodicals and book as indicated.

DATA ON SYNTHETIC AND NATURAL RUBBER IN THE USSR

[Numbers in parentheses refer to appended sources. Figures and tables referred to are appended.]

INTRODUCTION

The construction of a modern bomber requires about 700 kilograms of rubber. The construction of a tank, about 600 kilograms(1).

To establish a basis upon which the Soviet rubber industry could absolutely depend in war or peace, development in this field has been pushed in two directions: (1) intensive research has been conducted in the chemistry and technology of synthetic rubber, and (2) cultivation in the USSR of plants with yields of crude rubber sufficient in quantity and quality to warrant industrial exploitation has made great progress.

The synthetic rubber industry is of greater importance than the natural rubber industry because it is capable of greater development. The quality of synthetic products can be more closely controlled, and tailor-made elastomers and copolymerisates with any desired set of properties can be produced at will.

In addition, the economic advantages of producing rubber by synthetic methods may be emphasized. In order to produce 100,000 tons of natural crude rubber, 27 million Hevea trees must be cultivated on an acreage of 120,000 hectares and 550,000 man-years of labor expended. The production of 100,000 tons of synthetic rubber (from petroleum) requires the expenditure of only 150,000 man-years.

The postwar Five-Year Plan provides for doubling the production capacity of the synthetic rubber industry. This, of course, includes the reconstruction of plants which were destroyed by the Germans during the war. For instance, the first division of the Voronezh Plant imeni S. M. Kirov was completely reconstructed and modernized so that production could be resumed on 27 September 1947(2).

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The synthetic rubber industry was originally designed to use ethyl alcohol, a fermentation product derived from grain or potatoes, as the primary starting material. However, the goal has been set to base the synthetic rubber industry entirely on the cheaper ethyl alcohol made from wood cellulose, so that the present drain on valuable food products will no longer be necessary.

In 1950, 38 percent of the requirements of the synthetic rubber industry will be covered by the output of industrial plants manufacturing alcohol from cellulose, in accordance with the current Five-Year Plan(3).

The well-known method of manufacturing ethyl alcohol from ethylene, i. e., a by-product of the petroleum industry, also has been studied with the objective of providing a broader basis in raw material for the USSR's synthetic rubber industry.

In reviewing the development of the rubber industry in the USSR, it appears logical, then, that a better perspective will be gained by considering synthetic rubber first.

#### SYNTHETIC RUBBER

The USSR's synthetic rubber industry was created in 1931 - 1932 and is based on the work of S. V. Lebedev and his predecessors and collaborators. While it is difficult to assign credit to any one chemist in a development of this character, the work of Lebedev is particularly outstanding so far as immediate practical applications are concerned. At least, immediate application of Lebedev's results became possible after 1926, because the government decided in that year that the development of a synthetic rubber industry was desirable and practicable.

Lebedev started his research on the polymerization of conjugated diolefins (butadiene and its derivatives) as early as 1906. Basing his work on the known fact that isoprene (2-methyl-1, 3-butadiene) is the elementary compound from which the large molecules of natural rubber are built up and on the discovery of I. L. Kondakov (1898-1900) that 2,3-dimethyl-1, 3-butadiene, a purely synthetic homolog of butadiene obtained from acetone, also polymerizes and forms a substance which has the properties of natural crude rubber, Lebedev concentrated on butadiene itself and in 1908-1909 first obtained and studied butadiene rubber.

At about the time Lebedev completed his investigation, the German Dye-stuff Works at Elberfeld patented the synthesis of rubber from butadiene. The first commercial production of butadiene rubber (buna) took place in the USSR and was launched 5 years earlier than the first German venture in that direction. In Germany Buna was first produced in 1936.

In 1913, Lebedev published his classic monograph Investigations on the Polymerization of Diolefin Hydrocarbons. He established that both polymers and dimers (ethenyl-1-cyclohexene-3 in the case of butadiene) are formed as the result of the polymerization of these hydrocarbons and formulated the following relationships:

1. As the temperature rises, the quantity of the dimer increases, while that of the polymer diminishes.
2. At a constant temperature the ratio of the dimer to the polymer remains constant during the process of polymerization.

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3. The process of polymerization is easily influenced by the action of catalysts.

The practical importance of the first of the relationships listed above is self-evident: in order to obtain a good yield of synthetic rubber, the temperature must be kept as low as possible.

Lebedev's results concerning the influence of the structure of the monomer on the rate of polymerization can be summarized as follows:

1. In a series of isomers the rate of polymerization increases if the substituent is moved from the end atoms of the conjugated system to the middle atoms; a reverse displacement slows down the speed of polymerization.

2. Formation of a ring by a chain which bears a conjugated system increases the speed of polymerization.

3. In a homologous series, raising the mass of a substituent at a middle atom of the conjugated system increases the speed of polymerization, while an increase of the mass of a substituent at an end atom reduces that speed. This relationship holds if heating is carried out at the same temperature.

These relationships make it possible to predict on the basis of the structure of a hydrocarbon whether or not it will polymerize at a sufficiently great speed.

In 1926, the Soviet government announced a competition for a practicable and efficient process which would make the industrial production of synthetic rubber feasible, and result in a product of acceptable quality. Dimethyl rubber had been produced in Germany during World War I on the basis of Kondakov's process, but the quality of the product was generally regarded as inadequate. Only 2,350 tons had been produced up to the end of the war and the project was abandoned after the war because it proved to be uneconomical. Using his extensive experience in the field and doing some additional work on the subject, Lebedev participated in the competition and proposed an efficient method based on the use of butadiene as the starting material.

The jury recognized Lebedev's solution to the problem as the best, and adequate facilities for research and experimental industrial work (pilot plant production) were furnished him by the government. First of all, Lebedev and his collaborators tackled the problem of a satisfactory method for the production of butadiene. The earlier process of Ostromyslenskiy consisted of two steps: first, catalytic dehydrogenation of ethyl alcohol to acetaldehyde and then, in a separate stage, dehydration of acetaldehyde together with alcohol. Work done in 1920 had demonstrated that the yield of butadiene from Ostromyslenskiy's process did not exceed 5-6 percent. Lebedev proposed that a mixed catalyst over which both the dehydrogenation and the dehydration can be carried out in one stage be used in the conversion of ethyl alcohol to butadiene. This improved the yield considerably.

In choosing the catalyst for butadiene polymerization, Lebedev finally decided on sodium, although considerable prejudice against sodium had been evinced by Harries and his school, who claimed that "abnormal" rubbers must form in polymerizations catalyzed by an alkali metal. At that time, however, sodium was the correct choice, because the polymerization could be carried out in a short time with the aid of sodium and a good yield resulted. Other advantages were the low temperature at which the polymerization induced by sodium took place -- consequently a relative absence of dimers -- and the simple equipment in which the reaction could be carried out. Later on, especially as a result of investigations on the copolymerization of butadiene with styrene

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or derivatives of acrylic acid, the advantages of emulsion polymerization were realized and polymerization with sodium was gradually abandoned. At present it is held that a more uniform product of better quality results from emulsion polymerization.

The work done by Lebedev and his collaborators (Lebedev himself died in 1934) laid the scientific and technological foundation for the subsequent development of the Soviet synthetic rubber industry. Later work done by that school and other Russian chemists and technologists aimed at utilizing hydrocarbons derived from petroleum as a starting material for rubber production. The predominant part which depolymerization plays at high temperatures was noted. Lebedev's work on the polymerization of allene and its derivatives led to attempts to synthesize rubber from hydrocarbons which do not contain a conjugated system of double bonds, and polyisobutylene having an average molecular weight of 8,000 was synthesized (by Lebedev) at a temperature of -125 degrees. In this manner the synthesis of butyl rubber (Oppanol) has been closely approached.(4)

While the choice of alcohol as a starting material may have been a matter of necessity, Russian authorities point out the essential simplicity of the process which is being principally used in the USSR at present. The synthesis of butadiene by any other method requires many more steps. For instance, the synthesis which had been developed and applied by the Germans in the 30's (essentially the process proposed by Ostromyslenskiy in 1913) runs as follows:

1. Preparation of acetylene from calcium carbide.
2. Hydration of acetylene to acetaldehyde (reaction discovered by the Russian chemist Kutcherov).
3. Condensation of acetaldehyde to aldol.
4. Reduction of aldol to ethylene glycol.
5. Dehydration of ethylene glycol to butadiene.

For purposes of comparison, the synthesis of neoprene involves the following steps.

1. Preparation of acetylene from calcium carbide.
2. Catalytic polymerization of acetylene to monovinyl acetylene.
3. Synthesis of 2-chlorobutadiene by the addition of hydrogen chloride to monovinylacetylene.
4. Polymerization of the chlorobutadiene to neoprene.

Of course, neoprene is a special rubber which, strictly speaking, cannot be regarded as a substitute for natural rubber or buna and the other hydrocarbon rubbers. Because it has special applications, it is also produced in the USSR (under the name of Sovprene). Credit has been claimed by the USSR for the development of this type rubber (Academician N. D. Zelinskiy, Moscow University, and Prof A. Klebanskiy, Leningrad Institute of Applied Chemistry 1932(5)).

Even the comparatively simple synthesis of neoprene is more complicated than Lebedev's process for the production of butadiene rubber, which consists of only two steps, namely: (1) conversion of alcohol to butadiene, and (2) polymerization of butadiene (5a).

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[In drawing this sort of comparison, the steps leading to alcohol -- i.e., hydrolysis of cellulose, fermentation, etc. -- have been disregarded. Consideration of the economic and technological aspects of alcohol production brings us close to the problems which have been solved, or must be solved, in connection with the production of commercial rubber from the crude rubbers derived from plants which are grown for that purpose in the USSR, or occur there in a wild state.]

## NATURAL RUBBER

The war also stimulated the utilization of natural rubber derived from plants. Several technological improvements in this field date from that period. In this connection the saccharification of inulin under pressure in the complex treatment of rubber-bearing plants which contain rubber in their roots may be mentioned also the efforts to simplify the production of crude rubber from roots (particularly those of kok-saghyz) and to decentralize that production by carrying it out according to methods devised by D. I. Filippov in the localities where the plants are grown. The significance of these developments will be evident from the brief review of the over-all effort in the field of natural rubber which follows below. The production of natural crude rubber in the USSR from plants which are indigenous there or could be acclimated was seriously considered for the first time in the mid-1920's. A broad program of research and applied industrial development was started at that time and proceeded parallel to the development in the field of synthetic rubber which has been outlined above. It is impossible or very difficult to grow *Hevea brasiliensis* and other tropical members of that family in the Soviet Union. This also applies to other tropical plants, which, together with *Hevea brasiliensis*, are the most common sources of rubber and gutta-percha.

The Mexican plant guayule (*Parthenium argentatum* Gray), on which extensive work has been done in the USA, could be cultivated successfully in Central Asia and in the Caucasus, however. In 1939, more than 400 hectares of guayule were cultivated in Azerbaydzhan and Turkmenistan. In the future the kolkozoes of Azerbaydzhan presumably will become the chief source of supply of guayule. In those regions of the USSR in which this plant can be cultivated, yields in excess of 500 kilograms of industrial rubber per hectare have been obtained from plants 3-4 years old. An artificially irrigated guayule plantation in Azerbaydzhan has yielded as much as 717 kilograms of rubber hydrocarbon per hectare. These yields are obtained with artificial irrigation -- the absence of irrigation reduces the yields by a factor of from 2 to 2.5.

Another plant successfully acclimated to the USSR is the Chinese tree *Eucommia* (*Eucommia ulmoides* Oliv.). This was first brought to Russia in 1906 and used as a decorative plant. At present it is being successfully cultivated on the Black Sea coast of the Caucasus and the Crimea, in the Azov-Black Sea region, and in the Ukraine (Ustimovka). Plantations of various types of *Eucommia* already exist in Abkhaziya (Ochemchiry). The tree contains gutta-percha in all vegetative organs, but that product is obtained mainly by extraction with dichlorethane from the leaves. The leaves contain 2.3-3.0 per cent of gutta-percha on the basis of the absolute dry weight. Trees 20-25 years-old reach a height of 15-20 meters and have a well-developed crown. The prospects for successful production of gutta-percha from *Eucommia* are considered good.

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Bereskiet Borodavchaty (*Evonymus verrucosa* Scop.) is also considered a valuable industrial source of gutta-percha. This brush grows wild in the extensive forest regions of southern and eastern European USSR. The bark of its roots contains up to 8-15 percent gutta-percha and the bark coming from the Middle Volga region has a uniform content of 14-16 percent gutta-percha hydrocarbon. At present the wild plant is being utilized. One hectare of forest yields 3.5 to 53 kilograms of crude bark. Other types of beresklet, e.g., *Evonymus europea* L., also occur in the USSR, but their gutta-percha content is much lower. The richest type of beresklet, containing up to 20 percent gutta-percha in the bark, is the Japanese variety, but this type does not occur in the USSR. Problems in connection with the artificial cultivation of beresklet are still under investigation.

Vatochnik (*Asclepias cornuti* Des.), originally an American perennial herb, now grows in a wild state in southern European USSR. The resinous crude rubber derived from it has a low degree of polymerization, so that the product is not of particular value. The degree of polymerization can be raised, however, by subsequent treatment, and the plant is of interest because of the possibility of complete industrial utilization of all of its ingredients. One hectare of a 3-year-old plantation yields up to 200-300 kilograms of a resinous product containing 20-25 percent of crude rubber. The other useful products obtained from one hectare comprise 500 kilograms of fiber, 200-250 kilograms of floss, and 52-180 kilograms of oil.

The most important sources of crude rubber produced in the USSR are plants containing rubber principally in the roots, i.e., kok-saghyz, krym-saghyz, and tau-saghyz. These plants yield crude rubber of high quality. The resin content of the product is low in comparison with the crude rubber derived from plants which contain utilizable rubber elsewhere in the parenchym tissue, such as guayule or vatochnik (see Table 1). In addition to rubber hydrocarbons and resin, kok-saghyz roots contain sugar and inulin, which can be hydrolyzed to sugar (fructose). Both are starting materials for the production of alcohol by fermentation. Tens of thousands of hectares are already under cultivation with kok-saghyz at present.

Kok-saghyz is a perennial plant which shows rather wide variations of the yield depending on the soil and meteorological conditions. Thus, one-year-old roots from irrigated plantations in Central Asia contain 3.9-4.5 percent of rubber hydrocarbons, while similar roots from nonirrigated regions of European USSR have a rubber hydrocarbon content of 6.3-8.3 percent based on the absolute dry weight. The yield of seeds may reach 237 kilograms per hectare. The maximum yield of seeds takes place in the second year of the plant's life; in the third year, many plants deteriorate, and the yield of rubber is also diminished. Plants growing in the wild state have a somewhat longer life. Kok-saghyz has a very high rate of propagation and can be conveniently cultivated for that reason. By appropriate selection plants having larger roots could be developed and a maximum root weight of 200 grams (crude weight) could be achieved.

Tau-saghyz is a perennial plant is indigenous to the Kara-tau Mountains of Kazakhstan. The severe climate of that region has determined the characteristics of the plant and influenced its habitat. Rocky soil, low precipitation, cold winters, and dry, hot summers have conditioned the wild-growing tau-saghyz so that the plant has powerful roots, a comparatively small outer part, and, as far as its physiological characteristics are concerned, a brief period of active vegetation. The plant flowers in the second or third year of its life and then becomes dormant until the spring of the following year.

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The commercial cultivation of tau-saghyz has been delayed by the circumstance that the plant has a very low rate of propagation and growth. However, tau-saghyz is extremely adaptable: its characteristics can be changed rapidly under conditions of artificial cultivation. Its climatic adaptability is considerable: in addition to Kazakhstan and Central Asia, tau-saghyz can be grown successfully in the wooded steppes and steppe regions of European USSR. In the irrigated sections of Kazakhstan and Central Asia, fully productive plantations of tau-saghyz comprising hundreds of hectares are already under cultivation.

A method of collecting the rubber by cutting off the outer part of the plant has been developed. The milky juice flows from the roots and coagulates, forming crude rubber, which is removed by means of special pincers. Moderate cutting (ten to twelve times per season with a 4-day interval between cuttings) does not damage the plant; it is fully restored afterward. Tau-saghyz roots contain 12-15 percent benzene soluble rubber hydrocarbons on the basis of absolute dry weight and the roots reach a length of 10 meters and a thickness of 10 centimeters.

Krym-Saghyz is a perennial plant of the dandelion genus. It occurs in the wild state on the southern coast of the Crimea. The maximum weight of the crude root of cultivated plants is 200 grams, corresponding to an air-dry weight of 50-70 grams. In the first year of growth the roots collect only 0.7-0.8 percent of rubber as a rule, but in the second year that quantity increases to 3-5 percent on the basis of absolute dry weight, and even reaches 6 percent occasionally. Krym-saghyz is usually grown by planting seeds, but it also can be propagated vegetatively. The plant can be cultivated wherever an adequate snow cover protects the roots from freezing. It can also be grown in the warm regions of Central Asia and Transcaucasia. One hundred sixty centners of crude roots having a rubber content of 4.5 percent based on the absolute dry weight have been collected from a hectare of 2-year-old plantations in Central Asia. This corresponds to 200 kilograms of commercial crude rubber per hectare. The high rate of propagation, the high yields, and resistance to diseases make krym-saghyz a valuable rubber-bearing plant. It has been sown since 1940 on the kolkhozes of Central Asia and that territory will become in the near future the principal source of this type of raw material for rubber production.

Kok-saghyz is an important botanical source of supply of soft rubber in the USSR. Therefore, the production of crude rubber from kok-saghyz will be considered in some detail; furthermore, the methods in question can also be applied to other plants which yield the same type of crude material, i.e., rubber-bearing roots.

The chemical composition of the roots of kok-saghyz is shown in Table 4. The roots are composed of 17-19 percent cork, 70-72 percent bark parenchym (bark), and 9-11 percent wood. Tubes which carry the milky juice (latex) are disposed in concentric circles in the bark of the root. Cutting across the roots liberates the latex, which is washed out with water in one of the first stages of production. The flow charts showing industrial production of crude rubber from kok-saghyz are given in Figures 1 and 2.

On crushing or maceration in a root-grinding machine identical in construction with the grinding apparatus used in the manufacture of potato starch, the previously steamed material still contains most of its rubber in shreds of plant tissues which occlude the rubber. The walls of the plant tissue occluding the threads of rubber consist of cellulose, hemicellulose, lignin, and suberin (cork wax). Treatment with alkali or fermentation destroys these plant tissue walls and liberates the rubber. Either or both treatments can be applied prior to the next step, which consists of separating the rubber from the suspension. This concentration of rubber can be effected by settling,

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centrifuging, or flotation. Depending on the conditions, one or a combination of these methods can be used. Flotation is based on the differential wetting of rubber and other plant particles by water and gases. In other words, a foam process is used in order to float, and thereby concentrate, the rubber in the suspension.

Screening also effects concentration because the particles of rubber are larger than those of other plant material from which the rubber is to be separated. Rubber is stickier and has a greater tendency to agglomerate. This tendency is used to advantage in the separation of rubber by agglomeration, which method is illustrated on the right side of Figure 1. When dry roots of kok-saghyz or tau-saghyz are ground or crushed, the rubber agglomerates, but a fine powder of wood and other plant material sticks to the rubber and penetrates into it. If the disintegration is carried out in a ball mill in the presence of water, the moist particles of wood and other foreign material cannot adhere to the rubber, thus effecting the concentration and separation of the rubber from impurities, if the material is screened afterward. A typical flow chart depicting the production of crude rubber from kok-saghyz roots with the aid of ball mills, and without the use of alkali, is shown in Figure 3.

Commercial latex can be obtained only from fresh (living) roots, so that conditions of storage have to be controlled rather closely. According to Ignat'ev, Usina, and Erofejev (Kauchuk i Resina, No 1, 1940), the latex does not coagulate in the root in 30 days even at a temperature of 12 degrees centigrade. Figure 4 illustrates the production of latex according to the method devised by Ignat'ev.(6)

[Figures and tables follow.]

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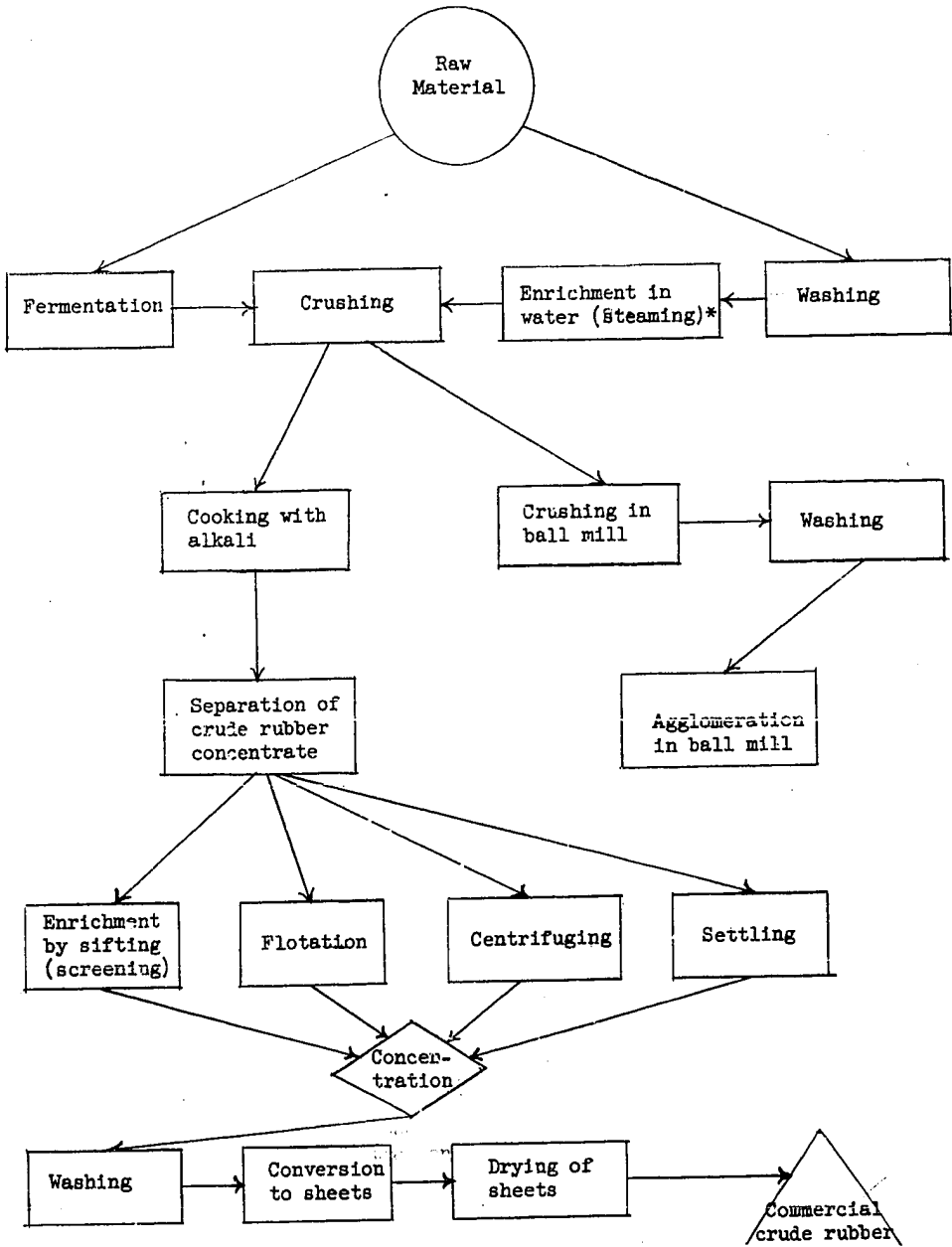
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Figure 1. Flow Chart Showing the Processing of Rubber-Bearing Roots (6)



\* Only water soluble material is removed

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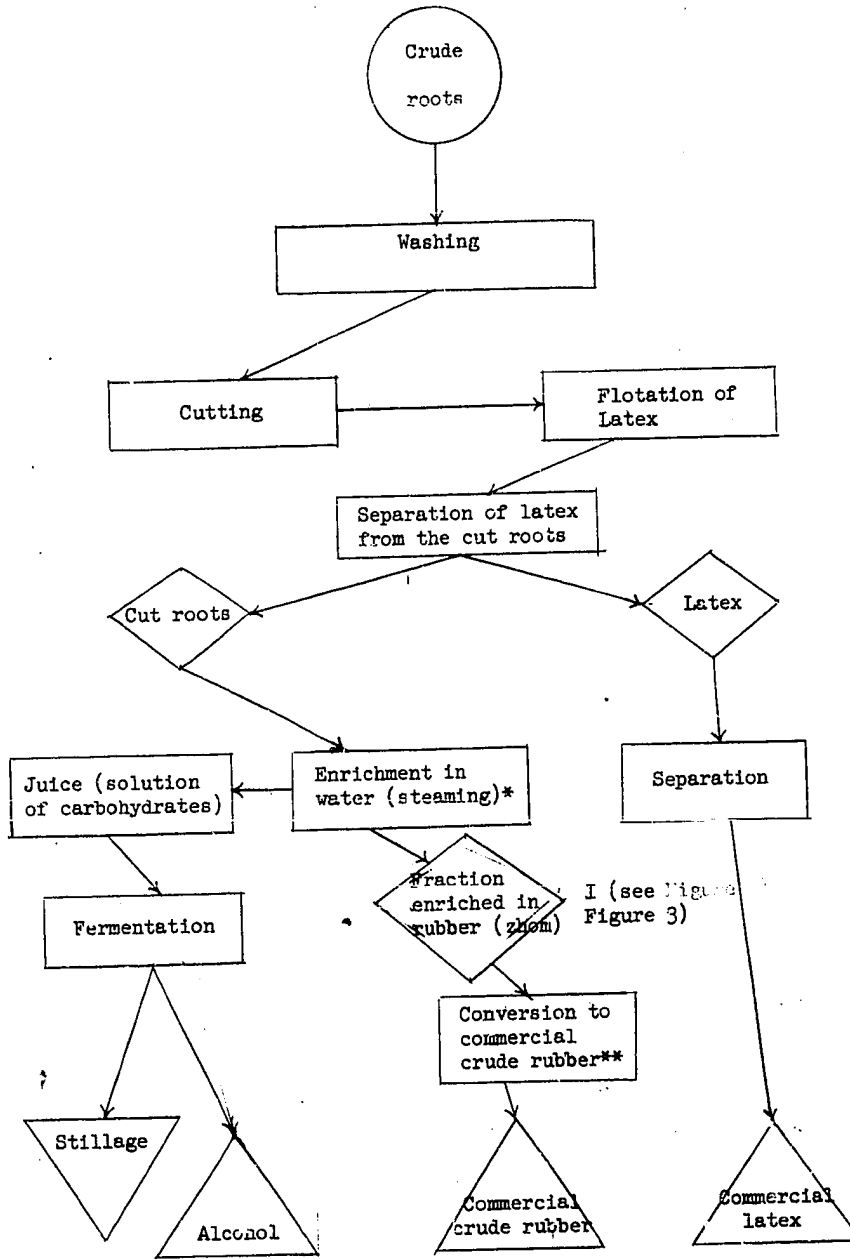
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Figure 2. Flow Chart Showing the Complex (Total) Processing of Rubber-Bearing Roots (6)



\* Only water soluble material is removed  
 \*\* Involves procedures shown in Figure 1

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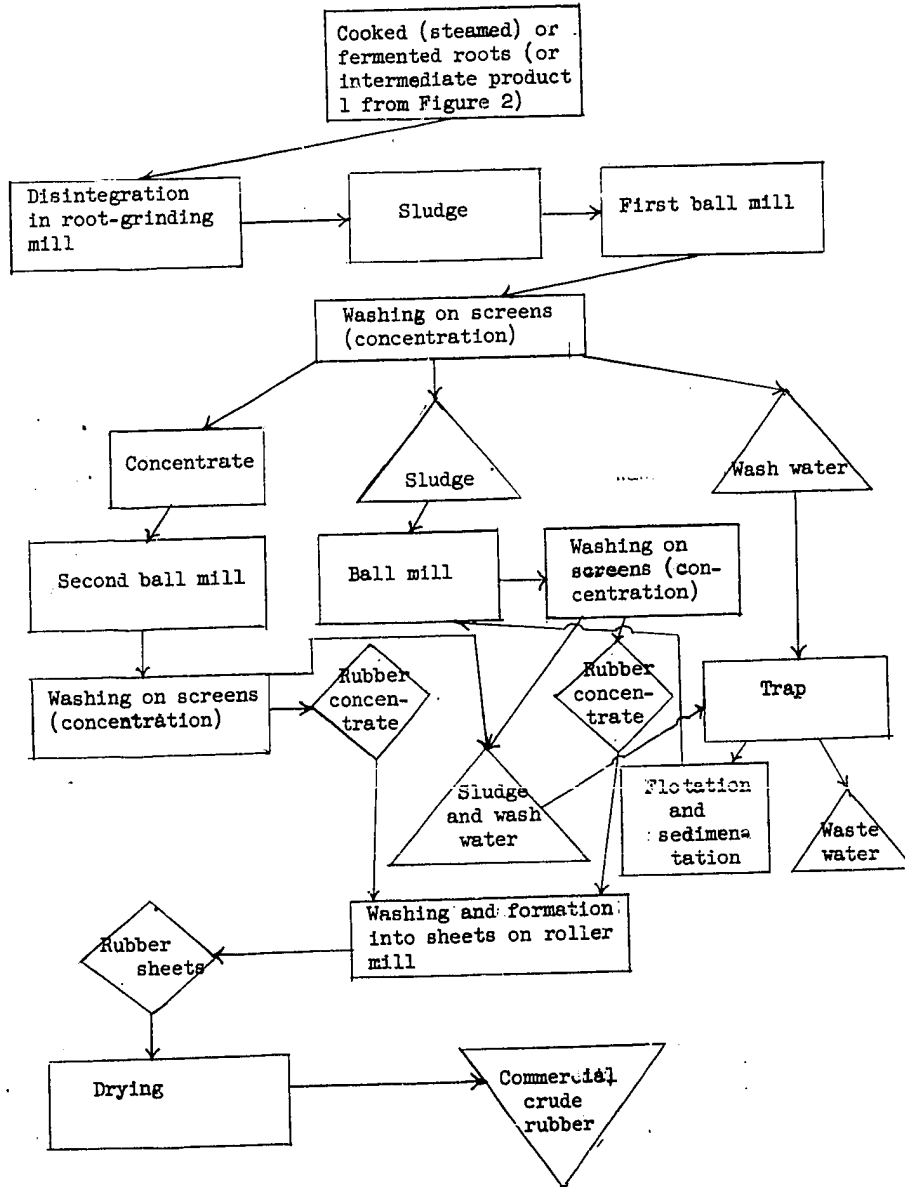
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Figure 3. Production of Crude Rubber from Kok-Saghyz with the Aid of Ball Mills (6)



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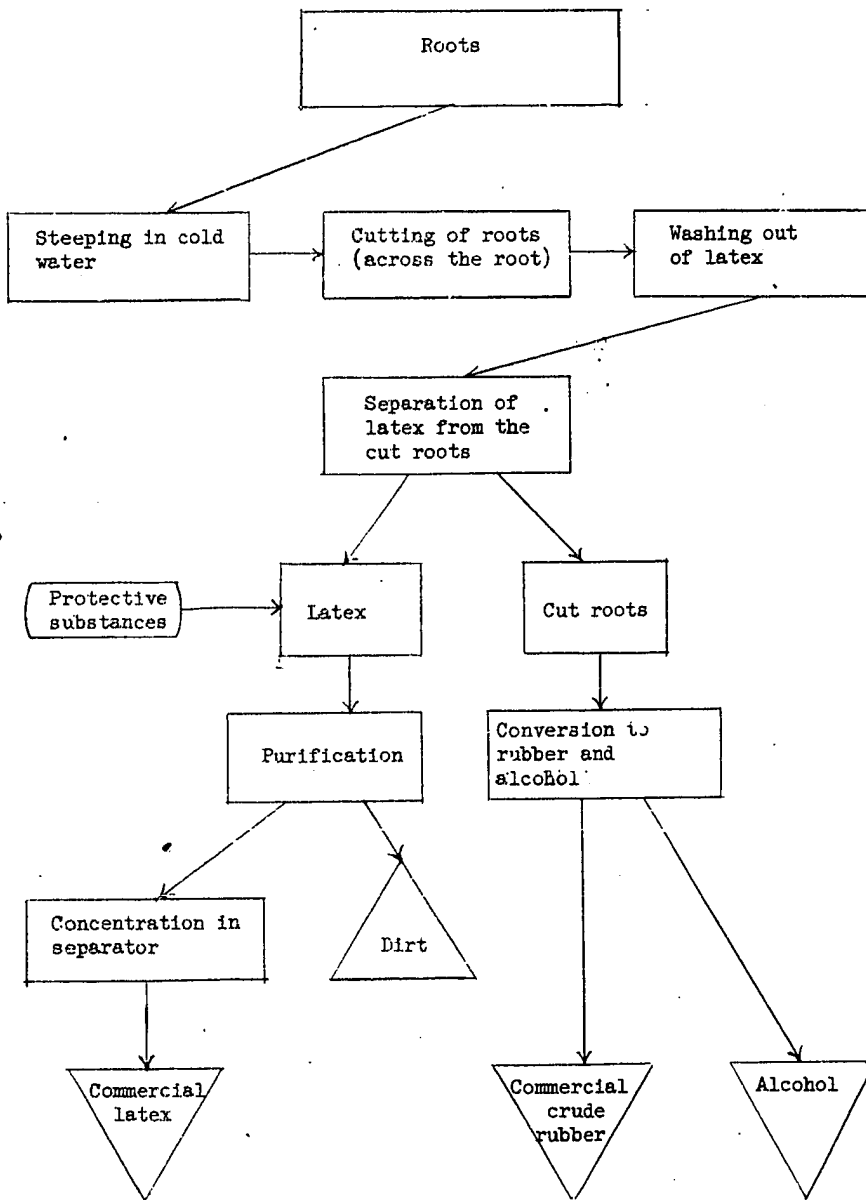
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Figure 4. Production of Commercial Latex (6)



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Table 1. Composition of Soviet Rubbers Compared with Hevea (b)

<u>Rubber-Bearing Plant</u>	<u>Processing Method</u>	<u>Commercial Product</u>	
		<u>Appearance and Form</u>	<u>Color</u>
Kok-saghyz (Taraxacum kok-saghyz Rodin)	Alkaline treatment	Sheets	Dark brown or dark gray
	Treatment in water	"	Dark gray
	Microbiological	"	Dark gray
	Complex	Latex	White
	Coagulation of latex	Sheets	Yellowish brown
Tau-saghyz (Scorzonera tau-saghyz Lipsch. et Bosse)	Alkaline treatment	"	Dark gray
	Coagulation of latex	"	Dark brown
Krym-saghyz (Taraxacum hybernum Stev.)	Alkaline treatment	"	Dark brown or dark gray
Guayule (Parthenium argentatum Gray)	Alkaline treatment	"	Dark green
Vatochnik (Asclepias cornuti Des.)	Extraction	Viscous, sticky mass	Dark green
Hevea (Hevea brasiliensis)	Coagulation with acid	Smoked sheets	Brownish red
	Coagulation with acid	Light crepe sheets	White
	Coagulation by spraying	Flakes	Grayish

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## Composition in % Based on Absolute Dry Weight

<u>Resin</u>	<u>Rubber Hydrocarbon</u>	<u>Substances Insoluble in Kerosene</u>	<u>Ash</u>	<u>Nitrogen</u>
10-11	83-86	4-6	1.5	0.50
10-11	80-85	5-10	1.5	0.59
10-11	83-86	4-6	1.5	0.62
3-4	40-50	0.1-0.3	0.5-1.0	1-1.25
6.4-8.0	90-91	-	0.6-1.0	1.2
3.6-6.0	87-90	5-7	1.1-1.9	0.50-0.9
5-6	88-90	3-4	1.5	-
10-12	83-86	4-6	1.3-1.6	-
19-30	63-78	2-3	1.6	-
55-73	25-40	-	1-1.5	-
3.10	93	-	0.31	2.4*
3.20	94	-	0.30	2.94*
4.25	88	-	1.20	4.26*

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Table 2. Composition of Various Grades of Gutta-Percha (6)

Type of Raw Material; Production Method	Content in % based on Absolute Dry Weight		Content in % Based on Absolute Dry Weight		Temperature of Softening According to Dittmar (in C)
	Gutta-percha Hydrocarbon	Resin	Substances Not Soluble in Kerosene	Water Content (in %)	
Gutta-percha from beresklet					
Alkali treatment	87-88	7-8	6-4	20-30	45-48
Extraction method	74-76	22.4-24.4	1.6	20-30	44.5-49.0
Gutta-percha obtained by alkali treatment from eucommia leaves					
	73.7	24.8	4.5-5.1	20-28	57
Imported gutta-percha					
Tiepetir	79	7	4	10	
Parang	57	14	11	18	
Goolia	45	32	9	14	
Serapong	39	31	3	27	

Table 3. Molecular Weight of Crude Rubbers

Sample	Degree of Polymerization	Molecular Weight	Author
Rubber hydrocarbon from hevea	2058	140.10 <sup>3</sup>	Staudinger, 1929
Rubber hydrocarbon from kok-saghyz	2573	175.10 <sup>3</sup>	Ignat'ev and Ustinova, 1938
Commercial rubber from kok-saghyz grown in regions of European USSR not artificially irrigated	2400-3000	203.10 <sup>3</sup> 165.10 <sup>3</sup>	Pinevich and Ignat'ev, 1939
Commercial rubber, from kok-saghyz grown in irrigated regions of Central Asia	1853-2735	188.10 <sup>3</sup> 126.10 <sup>3</sup>	Pinevich and Ignat'ev, 1939
Rubber hydrocarbon from tau-saghyz	2200	159.10 <sup>3</sup>	Ignat'ev and Ustinova, 1938
Rubber hydrocarbon from tau-saghyz	1868	127.10 <sup>3</sup>	Dogadkin, 1934

NOTE: The molecular weights have been determined from the specific viscosity of benzene solutions according to Staudinger.

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Table 4. Average Composition of Kok-Saghyz Roots (6)

<u>Components</u>	<u>Content (in %)</u>	
	<u>Based on absolute Dry Weight</u>	<u>Based on Raw (moist) Weight</u>
Rubber hydrocarbon (benzene extract)	7.40	2.22
Resins (acetone extract)	2.60	0.78
Carbohydrates (inulin and sugar)	38.00	11.40
Lignin, cellulose, proteins, and mineral and other components	52.00	15.60
Water	-	70.00

NOTE: Rubber Content of Kok-saghyz Leaves -- Maximum 1% based on absolute dry weight.

## Average Composition of the Natural Latex of Kok-Saghyz

Rubber hydrocarbon	30-45%
Resin	2-4 %
Carbohydrates	-
Protein	-
Ash	0.6-0.8%
Water	52-70 %

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Table 5. Conversion of Kok-Saghyz Roots into Rubber and Alcohol Using Alkaline Treatment and Centrifuges (6)

Product	Anhydrous Material Content (in %)	Components of Anhy- drous Material (in %)			Distribution Accord- ing to Stages in the Flow of Material in % Based on a 100% Con- tent in Crude Roots				Materials per Ton of Com- mercial Rubber (in tons)
		Rubber Hydro- carbon	Resin	Insolu- ble Sub- stances	Total Crude Weight	Dry Matter	Rubber Hydro- carbon		
Kok-saghyz roots	30.0	7.4	2.7	-	100	100	100	41.0	
Fraction enriched in rubber (zhom)-- see Fig 22	9.7	15.7	6.3	-	146	47	100	59.9	
Diffusion juice	10.6	-	-	-	151	53	-	61.9	
Absolute alcohol	100.0	-	-	-	-	13.9	-	1.7	
Suspension									
At the start of cooking	11.4	13.1	-	-	149	57	100	61.1	
Before cen- trifuging	6.3	13.1	-	-	273	57	100	111.9	
Centrifuging:									
Concentrate	30.0	76.8	8.2	15.0	7	7	75	2.95	
Sludge	11.0	12.3	-	-	33	12	20	13.3	
Filtrate	4.8	0.99	-	-	232	37	5	95.1	
Treatment of sludge									
Sludge	11.0	12.3	-	-	33	12	20	13.3	
Rubber concen- trate from sludge	10.1	78.8	8.3	12.9	4.6	2	18	1.88	
Filtrate	1.0	1.4	-	-	305	10	2	125.7	
Washed concentrate	20.0	78.3	8.8	12.9	13	9	91	5.3	
Moist rubber sheets	60.0	83.2	10.1	6.7	4	8	90	1.64	
Dry rubber sheets	98.5	83.2	10.1	6.7	2.4	8	90	1.00	

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Table 6. Production of Rubber from Kok-Saghyz Roots with Aid of Alkaline Treatment and under Separation of Rubber Concentrate by Flotation

Product	Anhydrous Material Content (in %)	Components of Anhydrous Material (in %)			Distribution According to Stages in the Flow of Material in % Based on a 100% Content in Crude Roots			
		Rubber Hydrocarbon	Resin	Insoluble Substances	Total Crude Weight	Dry Matter	Rubber Hydrocarbon	Materials Per Ton of Commercial Rubber (in tons)
Kok-saghyz roots	30.0	7.4	2.7	-	100	100	100	41.0
Fraction enriched in rubber (zhom)--- see Fig 2	9.7	15.7	6.3	-	146	47	100	59.9
Suspension								
At the start of cooking	11.4	13.1	6.0	-	149	57	100	61.1
Before charging into the flotation unit	9.5	13.1	6.0	-	179	57	100	73.4
Flotation								
Suspension diluted in the flotation process	1.0	13.1	6.0	-	1430	57	100	586.1
1st concentrate	17.0	71.9	5.8	22.3	15	8	80.5	6.2
1st sludge	8.6	24.9	-	-	15	4	14.5	6.2
1st filtrate	0.95	0.84	-	-	1400	44	5	5.7
Washing of concentrate								
2d concentrate	24.7	78.6	8.9	12.5	8	7	73.8	3.4
2d sludge	8.6	33.6	-	-	3.6	1	4.7	1.48
2d filtrate	0.2	49.9	-	-	44	0.4	2.0	190.4
Treatment of sludge								
Sludge	8.6	26.6	-	-	18.6	5.3	19.2	17.62
Concentrate	13.4	78.4	8.7	12.9	3.6	1.6	17.2	1.48
Filtrate	0.2	39.6	-	-	179	3.7	2.0	7.15
Washed concentrate	21.3	78.6	8.8	12.6	12	8.5	91	4.92
Moist rubber sheets	60.0	83.2	10.1	6.7	4	8	90	1.69
Dry rubber sheets	98.5	83.2	10.1	6.7	2.4	8	90	1.00

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Table 7. Conversion of Kok-Saghyz Roots into Rubber and Alcohol without Use of Alkali and with Aid of Ball Mills (6)

Product	Anhydrous Material Content (in %)	Components of Anhydrous Material (in %)			Distribution According to Stages in the Flow of Material in % Based on a 100% Content in Crude Roots			
		Rubber Hydro-carbon	Resin	Insoluble Substances	Total Crude Weight	Dry Matter	Rubber Hydro-carbon	Materials Per Ton of Commercial Rubber (in tons)
Kok-saghyz roots	30.0	7.4	2.7	-	100	100	100	41.0
Fraction enriched in rubber (zhom)-- see Fig. 2	9.7	15.7	6.3	-	146	47	100	59.9
First passage through ball mill and screen assembly								
Sludge	9.66	15.7	6.3	-	146	47	100	59.9
First half-finished product	30.0	67.5	8.0	24.5	10.2	10	93	4.2
Filtrate	0.8	1.44	-	-	137.6	37	7	564.0
Second passage through ball mill and screen assembly								
Suspension	11.2	67.5	8.0	24.5	27.4	10	93	11.25
Concentrate	40.0	80.5	8.5	11.0	6	8	91	2.5
Filtrate	0.2	7.6	-	-	260	1.8	2	104.6
Moist rubber sheets	60.0	83.2	10.1	6.7	4	8	90	1.64
Dry rubber sheets	98.5	83.2	10.1	6.7	2.4	8	90	1.00

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