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БАЯНДАМАЛАРЫ

ДОКЛАДЫ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН

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TABLE OF CONTENTS AND LOCALIZATION OF RUBBER IN THE ROOTS OF KOK-SAGHYZ (*Taraxacum kok-saghyz Rodin*)

Abstract. This article presents biological features, botanical description, and the results of the anatomical and physiological study of the Dandelion kok-saghyz (*Taraxacum kok-saghyz* Rodin), a valuable resource plant of world significance. Kok-saghyz is used as a technical culture, a source of high-quality rubber.

Natural rubber is widely used in the rubber industry for the production of tires for automobiles, aircrafts, bicycles, as well as shoes, medical gloves and other products.

The global rubber industry faces the real danger of the destruction of plantations of the main source of natural rubber - the rubber tree of hevea (*Hevea brasiliensis*), grown in the tropical humid climate of Southeast Asia, due to its diseases. This has happened in South America, which was originally a world center for the production of natural rubber; it has completely lost its position due to epiphytotics. There is currently a phytosanitary quarantine and a person who was accessed to hevea in South America should not visit the countries of Southeast Asia.

Thus, there is a need for reserve additional plant species, the sources of natural rubber in the temperate zone, being adverse for acclimatization of hevea. Dandelion kok-saghyz is recognized as such a promising producer of natural rubber.

According to data published, rubber of kok-saghyz sits in the latex vessels of the root, and the rubber content (6 to 14%) depends on the number of circles of the latex vessels (3 to 14). The number of circles of the latex vessels and, therefore, the rubber content in the roots depends on genotype, agricultural background and stage of kok-saghyz ontogenesis.

The roots of kok-saghyz are known for high variability in the rubber content even in the same natural population of wild kok-saghyz from 0 to 47.87; 35.85 and 23.58% of the air-dry weight is due to several one-year covers in the root.

Kok-saghyz is a highly polymorphic species that can be used in breeding programs. Individual selection provides for the high rubber content in the roots of kok-saghyz (10 to 14%).

Currently, kok-saghyz is an important rubber plant with the following features: 1) high percentage of rubber; 2) flowering and fruiting in the first year of life; 3) high quality rubber. Kok-saghyz polymorphism provides for the selection of the most rubber-bearing and most precocious forms of this plant.

Keywords: kok-saghyz, rubber, latex vessels.

The main part. Problem. The purpose of this article - collection, analysis and discussion of the information about rubber content and location in the roots of the kok-saghyz (*Taraxacum kok-saghyz Rodin*).

Natural rubber (NR) is a strategically important material in the world industry. NR is used in rubber industry and in production of a wide range of goods: shoes, clothes, catheters, surgical gloves, tires for planes and cars as well as other goods [1, 2]. Kok-saghyz rubber has great prospects as an additive to bioplastics for the manufacture of biopackages with improved strength [3, 4].

In 2016 the world NR market amounted approximately up to $ 24 bln with the consumption volume of 12.9 tons, and by the year of 2023 it is estimated that its consumption will increase up to 16.5 mln tons (International Rubber Study Group -IRSG).

The main sources of rubber are plantations of rubber woods- hevea (*Hevea brasiliensis*), grown in tropical humid climate of the South- Eastern Asia. Currently hevea plantations and consequently the world market of natural rubber face the following threats [5].

1. The threat from fungus parasite (*Microcyclus ulei*), which causes mass infection and the death of rubber trees as it happened in the South America, originally it has been the world center of natural rubber production but completely lost its stand due to epiphytotic.

At present we see phyto-sanitary quarantine there and individuals being in contact with hevea in the South America are not recommended to visit countries of the Southeast Asia. Fungus spores are being preserved on the human skin and clothes. Scientists are of the opinion that fungus parasite to crop up in the South-Eastern countries housing the world's leading natural rubber producers is just a matter of time. The UN Security Council classified *Microcyclus ulei*, as the type of the new biological weapon [6].

2. The year of 2024 must see development of up to 10 million hectares of the new rubber plantations. This level of hevea plantations enlargement will have a catastrophic effect on the biological diversity of the South-Eastern Asia [5].

The problem of the global rubber industry lies in the real danger of the destruction of plantations by diseases of the main source of natural rubber - the rubber tree of hevea.

Thus, reserve, additional, alternative plants as rubber source are needed in the area of temperate climate where hevea is not able to get adapted. Dandelion kok-saghyz is such a perspective producer of natural rubber. Natural rubber derived from kok-saghyz roots does not concede in quality the standard hevea rubber [3]. Moreover, the natural rubber of kok-saghyz has some advantages over hevea natural rubber as it does not contain allergenic which are characteristic to natural rubber of hevea [7].

Kok-saghyz, as a rubber producer, was discovered in 1932 by the botanist L.E. Rodin in the intermountain valleys of the Eastern Tien Shan of Kazakhstan [8].

From the thirties to the mid-fifties of the last century, kok-saghyz was grown in the former Soviet Union, however, after the opening of synthetic rubber and lifting the blockade from industrial plantations of hevea of Southeast Asia, work with kok-saghyz was stopped [9].

Since the beginning of the 21st century, in connection with threats to the hevea plantations and the global NK market, the studies of kok-saghyz have been resumed, aimed at organizing its industrial plantations in the USA, European Union countries, Russia, Korea, Japan and Kazakhstan [10-12].

Kok-saghyz is a perennial herbaceous, cross-pollinated plant, a plant of the genus Dandelion, the Asteraceae family, diploid (16 chromosomes) species.

The aerial part of the kok-saghyz plant is a rosette of 20-25 leaves tightly pressed to the ground. The leaves of the kok-saghyz are fleshy, bluish-green, without pubescence. They are whole-extreme, incised, dissected. By the time of flowering, kok-saghyz ejects tubular peduncles from the central part of the outlet, with baskets at the end.

Dandelion flower is not one flower, but a whole basket of tubular flowers with fused petals and stamens. Dandelion has a special system of green leaves surrounding the receptacle and supporting a basket called a wrapper. The wrapper protects the flowers in the basket by hiding them in rainy weather so as not to waste precious pollen. The root of kok-saghyz in wild populations is pivotal, in the culture it is often fibrous.

The main features by which kok-saghyz differs from other types of Dandelion are:

- the outer and inner leaves of the kok-saghyz wrapper end flower with a 2.5-5 mm horn-shaped appendage, bent at a right angle;
- smaller flower baskets have a lemon tint;
- kok-saghyz leaves do not have sharp spines along the edges;
- the rubber content in the root is high, above 6%, reaches 8-12%, in terms of the dry weight of the root [8,13].

The maximum amount of rubber is in the roots. Rubber is found in special vessels called the latex vessels. In them, it is in the form of milky juice - latex. During coagulation of rubber in the latex vessels, elastic threads are formed. In the root, the latex vessels are located in concentric circles in the parenchyma of the external (cortical) tissue.

The root structure of the biennial kok-saghyz plant is shown in Figure 1.

Numerous rows of latex vessels scattered between the xylem and the layer of the inner traffic jams are scattered behind the cambial ring in the parenchyma.

Next, between the inner and outer plugs is part of the root, also filled with rows of latex vessels. Outside, at the periphery of the root, cork layers lie under which layers of rubber are visible. The latex

vessels are located in the cortical part, and those of them that make up the rings located to the periphery itself and under the layer of the inner tube have the greatest power. There are from 2 to 14 rows (rings) of milky vessels.

The inner ring of the traffic jams cuts off the parenchyma lying outside of it with latex vessels enclosing the threads. The parenchyma gradually dies, and the external latex vessels with rubber threads exfoliate along with the cork. The outer traffic jams is multi-layered. Its peeling is especially noticeable in the spring; by the onset of summer, the cork layer becomes thinner. With an average rubber content of 8-12% in the root wood, the biennial cover also contains about 8-12%.

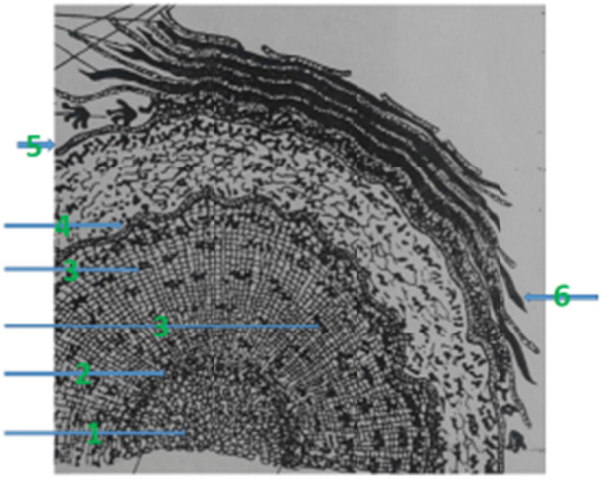

Figure 1 - Cross section of the root of the kok-saghyz (*Taraxacum kok-saghyz* Rodin). In the center of xylem (1), cambium (2) behind it. After him there are rows of latex vessels (3) in the cortical parenchyma enclosed between the xylem and the layer of the inner traffic jams (4). Further, the root part, enclosed between the inner and outer traffic jams, with rows of latex vessels. To the outside are cork layers with layers of rubber lying (6) under them [8]

In the roots, the rubber is distributed along the length in such a way that its quantity gradually increases to a known depth (up to about 20 cm, counting from the root neck), and then begins to gradually decrease, as shown in table 1.

Table 1 – The rubber content in individual segments of the root of kok-saghyz [8]

The depth of the root collar (in cm)	Rubber, %
0-5	11,47
5-10	21,11
10-15	27,20
15-20	27,87
20-25	-
25-30	23,92

Since the latexk vessels are the only container of rubber in the roots of kok-sagyz, the rubber-bearing capacity of the latter depends on the number and size of the latex vessels, as well as on the degree of saturation of the latex juice (latex) with rubber. The latex of the roots of annual plants contains 30–35% of rubber, from 6 to 15.5% of non-rubber substances (tarry substances, disaccharine, inulin, etc.) and 50–60% of water. The primary system of latex vessels is formed from the moment of seed germination near the sieve tubes. Rubber is formed in the roots of seedlings on the first day of seed germination, regardless of lighting, that is, in the absence of photosynthesis.

In the three-week-old seedlings, the system of latex vessels forms 2-3 circles. By the flowering period, the latex vessels form 8–9 concentric circles. During fruiting, the number of circles of the latex vessels reaches 10–13, the rubber content increases.

Towards the end of the growing season, the amount of rubber in the latex vessels is somewhat larger than at the time of fruiting [14, 15].

In the second year of vegetation, an inner cork develops in the roots of kok-saghyz and a “rubber cover” forms. Only in wild two or three year old plants, under conditions of slow decay of the cover, roots with several rubber covers were observed [8].

Latex globules have a complex structure. The outer layer is formed by proteins, lipids, fatty acids and other surfactants contained in latex. The next layer consists of hard elastic rubber. Finally, the inner part of the globule – the bulk of it – is also a rubber hydrocarbon that, in consistency, resembles a very viscous liquid [16].

The concentration of rubber in latex by the end of the growing season may increase by 3 times.

It has been established that the number of latex vessels depends on the agricultural background and climatic conditions. The upper zones of the root are the least poor in latex vessels , the zones most saturated are 12–25 cm distant from the root neck. For example, the lateral roots (younger than the main) have 203 latex vessels per 1 mm^2, and the main ones –164 [14].

Table 2 shows the exceptional variability of kok-saghyz in terms of rubber content even in the same thicket, which is especially significant in the Chelkudysu valley. In which these fluctuations are recorded from 0 to 47.78%. There are facts that indicate that, when individually selected, a high rubber content within certain limits of variability can be retained in subsequent offspring.

The natural thickets of kok-saghyz are the most valuable fund from which material for individual selection will be taken all the time. Therefore, it is quite rational to organize a nature reserve in the area of natural thickets of kok-saghyz.

Table 2 – The rubber content in the roots of kok-saghyz for individual thickets in the Tien Shan [8]

Valley name	Analysis date	The rubber content in the roots of kok-saghyz to air-dry weight,%		
Tekes	21VI- 27/ VII	0,00	8,80	35,85
Saryzhaz	8/VII	0,00	7,80	23,58
Kegen	16/VII	1,18	3,29	6,86
Chelkudysu	24/VII	0,70	10,66	47,87
Ashily	9/VII	1,56	5,35	13,63
Karkara	27/VII	1,83	4,03	10,08
Salt Lake	28/VI	0,00	5,25	9,9

Such a high rubber content in the roots of wild plants of кок-saghyz: 47.87; 35.85 and 23.58% to air-dry weight can be explained by the presence of several rubber covers at the root [8].

There are conflicting opinions on the role of rubber in a plant:

1. Rubber, in the form of latex (milky juice) - a plant protection product against fungal and bacterial diseases, as well as mechanical damage. Coagulated rubber in the form of a cover - protection against excessive consumption of moisture by the root and from high temperatures.
2. Rubber-excretion - garbage is formed as a by-product in the metabolism.
3. Rubber is a reserve nutrient that can be used by plants.

Thus, at present, kok-saghyz is the most important plant species - a source of rubber, due to its following features: 1) high percentage of rubber and its favorable location, 2) flowering and fruiting in the first year of life, 3) high quality of rubber. Kok-saghyz polymorphism allows counting on the selection of the most rubber-bearing and most precocious forms of this plant.

The roots of kok-saghyz with the participation of xylem and latex vessels located in successive circles were found; this structure resembles that of beets.

Under culture, kok-saghyz undergoes significant changes. In natural thickets, the weight of the root is about 1 g. On good plantations, the average weight of the root reaches 10 g. With root enlargement, there is a slight decrease in the percentage of rubber, however, the total amount of rubber per root is higher in the culture than in natural thickets. If in these thickets about 100 mg of rubber falls on one plant, then in the culture the average amount of rubber on one plant reaches 200-250 mg.

A particularly significant increase in the root of the kok-saghyz is obtained when grown on a high agricultural background. Individual roots in nesting crops reaches a weight of 100-150 g or more.

The largest roots were obtained by breeders when grown on a good agricultural background and solitary standing. The weight of large roots from seed sowing reaches 100-150-200 g, from cuttings

250–300 g. The largest roots were obtained in Gorki Leninsky from cuttings, the root weight reached 380 g. The diameter of the root neck of such a root is equal to large carrots. Although the rubber in such roots is usually about 2%, the absolute amount of rubber in such a root is 5-7 g.

However, roots of this magnitude were grown in separate copies on cuttings. In the future, when cultivating plantings by cuttings and growing on a high agricultural background, it is possible to achieve mass enlargement of the roots and consolidation of these qualities in the off spring.

To date, there is a variety of kok-saghyz "Saryzazh" in Kazakhstan (Institute of Plant Biology and Biotechnology, Almaty, Kazakhstan), which is characterized by high environmental plasticity and can be used as an annual culture [17].

In a selective way, the rubber content in the root of kok-saghyz can be brought up to 25% [18]. It is assumed that when hybridizing with T.fficinale, which has large roots, you can get hybrids with a rubber content of 20%, theoretically, a rubber crop of up to 1800 kg / ha can be obtained [1, 19].

Conclusion. Natural rubber is indispensable synthetic in the manufacture of a wide range of products: tires for aircraft, automobiles, shoes, clothing, surgical gloves and other products.

The problem of the global rubber industry lies in the real danger of the destruction of plantations of the main source of natural rubber, the rubber tree of Hevea (*Hevea brasiliensis*), grown in the tropical, humid climate of Southeast Asia, by diseases.

In this regard, in the temperate climate zone, Dandelion kok-sagyz (Taraxacum kok-saghyz) is being introduced into the culture as an additional source of hevea for natural rubber.

It has been established that the rubber of kok-saghyz is located in the latex vessels of the root and the rubber content in the root (from 6 to 14% on the dry weight of the root) depends on the number of circles of latex vessels from 3 to 14. The number of circles of latex vessels depends on the genotype, agricultural background and stage of ontogenesis

In the second year of the growing season of kok-saghyz plants, new circles of latex vessels with rubber are formed in its roots, and latex vessels of last year with rubber threads form a rubber cover around the root. Thus, the rubber content of biennial plants doubles. In the thickets of wild kok-saghyz, kok-saghyz plants with several annual covers and, accordingly, plants with an increased rubber content were found.

Kok-saghyz is a highly polymorphic species, which allows it to be used in breeding programs aimed at increasing the productivity and stability of this promising technical culture.

The content of rubber can be brought up to 25% by selection. Hybridization with *Taraxacum officinale*, which has large roots, you can get hybrids with a rubber content of 20%, theoretically a rubber crop of up to 1800 kg / ha can be obtained.

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КӨК-САҒЫЗ ТАМЫРЫНДАҒЫ КАУЧУК МАЗМҰНЫ МЕН ОРНАЛАСУЫ (*Taraxacum kok-saghyz* Rodin)

Аннотация. Мақалада көк-сағыз бақбағының (*Taraxacum kok-saghyz* Rodin) әлемдік маңызы бар бағалы ресурстық өсімдіктің биологиялық ерекшеліктері, ботаникалық сипаттамасы, анатомиялық-физиологиялық зерттеу нәтижелері келтірілген. Көк-сағыз техникалық мәдениет ретінде жоғары сапалы каучук көзі пайдаланылады.

Табиғи каучук (ТК) автомобиль, ұшақ, велосипедтерге, сондай-ақ аяқ киім, медициналық қолғап және басқа да тауарларға арналған резеңке-техникалық өнеркәсібінде кеңінен қолданылады.

Әлемдік резеңке өнеркәсібі мәселесі табиғи каучук негізгі көзі – гевея каучук ағашының плантациясы жойылудың нақты қауіптілігіне негізделеді. Оңтүстік-Шығыс Азия елдерінің тропикалық, ылғалды климатында өсірілген (*Hevea brasiliensis*). Бұл Оңтүстік Америкада бастапқыда табиғи каучук өндірісінің әлемдік орталығы болды, бірақ эпифитотия салдарынан позициясын толығымен жоғалтты. Қазіргі кезде фитосанитарлық карантин қолданылады және Оңтүстік Америкада гевеяға жақындаған адамға Оңтүстік-Шығыс Азия елдеріне келуге болмайды.

Осылайша гевея акклиматтала алмайтын әлсіз климат аймағында каучук көзі ретінде балама, қосымша өсімдіктер қажет. СК осындай перспективалы продуцент деп бақбақ көк-сағызы танылды (*Taraxacum kok-saghyz* Rodin).

Жарияланған мәліметтерге сәйкес, көк-сағыз каучук тамыр сауытында орналасқан және каучук мөлшері (6-дан 14%-ға дейін) сауыт шеңберінің санына байланысты (3-тен 14%-ға дейін). Сүт тамыры шеңберінің саны

және демек тамырлардағы каучук мөлшері генотипке, агрофонға және көк-сағыз онтогенезінің кезеңіне байланысты.

Сүттілік жүйесі үш апталық көк-сағыз көшеттері 2-3 шеңберде пайда болады. Гүлдену кезеңіне қарай құс ыдыстары 8-9 концентрациялы шеңбер құрайды. Жеміс беру кезеңінде сүт тамырлары шеңберінің саны 10-13-ке жетеді, каучук мөлшері артады.

Вегетация соңында сүт ыдыстарындағы каучук мөлшері жеміс беру кезеңіне қарағанда біршама көбірек. Көк-сағыз өсімдіктерінің өсіп-өнуінің екінші жылында оның тамырында каучугы сауыттардың жаңа шеңбері пайда болады, ал өткен жылғы каучук жіптері бар сауыттар каучук қабының пайда болуы негізінде қабыршақтанады. Осылайша екіжылдық өсімдіктерде каучук құрамы екі есе өседі.

Көк-сағыз тамырындағы каучук мөлшері бойынша бір табиғи популяцияның өзінде 0-ден 47,87-ге дейін; 35,85 және 23,58% ауа-құрғақ салмағының тамырында бірнеше жылдық тыстармен түсіндіруге негіз бар.

Көк-сағыздың табиғи өсінділері – жеке іріктеуге арналған материал болатын құнды қор. Сондықтан көк-сағыз табиғи өсінділері ауданында қорықшаны ұйымдастыру өте тиімді.

Көк-сағыз жоғары полиморфты түр болып саналады әрі селекциялық бағдарламаларда пайдалануға мүмкіндік береді. Жеке іріктеу кезінде көк-сағыз тамырындағы каучуктың жоғары мөлшері (10-14 %) мұраға қалдырылады.

Қазіргі уақытта көк-сағыз келесі ерекшеліктері арқылы маңызды көк сағыз өсімдігі болып саналады: 1) каучуктың жоғары пайыздық құрамы және оның тиімді орналасуы; 2) өмірдің бірінші жылында гүлдену мен жеміс-жидек; 3) каучуктың жоғары сапасы. Көк-сағыз полиморфизмі аталған өсімдіктің каучугы мен жылдам пісетін нысандарын іріктеуге мүмкіндік береді.

Түйін сөздер: көк-сағыз, каучук, сүтті тамырлар

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СОДЕРЖАНИЕ И ЛОКАЛИЗАЦИЯ КАУЧУКА В КОРНЯХ КОК-САГЫЗА (*Taraxacum kok-saghyz* Rodin)

Аннотациия. В статье приведены биологические особенности, ботаническое описание, результаты анатомо-физиологического изучения Одуванчика кок-сагыз (*Taraxacum kok-saghyz* Rodin) – ценного ресурсное растения мирового значения. Кок-сагыз используется как техническая культура – источник высококачественного каучука.

Натуральный каучук (НК) широко используется в резинотехнической промышленности для произ-водства шин для автомобилей, самолетов, велосипедов, а также обуви, медицинских перчаток и других товаров.

Проблема мировой резиновой промышленности заключается в реальной опасности уничтожения болезнями плантаций основного источника натурального каучука – каучукового дерева гевеи (*Hevea brasiliensis*), выращиваемого в тропическом, влажном климате стран Юго-Восточной Азии, как это случилось в Южной Америке, которая изначально была мировым центром производства натурального каучука, но из-за эпифитотии полностью утратила свои позиции. В настоящее время существует фитосанитарный карантин и человеку, имеющему доступ к гевее в Южной Америке, не рекомендуется посещение стран Юго-Восточной Азии.

Таким образом, необходимы резервные, дополнительные виды растений – источники НК в зоне умеренного климата, где гевея не может акклиматизироваться. Таким перспективным продуцентом НК признан одуванчик кок-сагыз (*Taraxacum kok-saghyz* Rodin).

Согласно опубликованным данным, каучук кок-сагыза находится в млечных сосудах корня, и содержание каучука (от 6 до 14%) зависит от количества кругов млечных сосудов (от 3 до 14). Количество кругов млечных сосудов и, следовательно, содержание каучука в корнях зависит от генотипа, агрофона и этапа онтогенеза кок-сагыза.

Млечная система образует у трехнедельных сеянцев кок-сагыза 2–3 круга. К периоду цветения млечные сосуды образуют 8–9 концентрических кругов. В период плодоношения количество кругов млечных сосудов достигает 10–13, содержание каучука увеличивается.

К концу вегетации количество каучука в млечных сосудах несколько больше, чем в момент плодоношения.

На второй год вегетации растений кок-сагыза в его корнях образуются новые круги млечных сосудов с каучуком, а млечники прошлого года с нитями каучука отшелушиваются с образованием каучукового чехла. Таким образом, содержание каучука у двухгодичных растений удваивается.

Известна высокая изменчивость по содержанию каучука в корнях кок-сагыза даже в одной и той же природной популяции дикого кок-сагыза от 0 до 47,87; 35,85 и 23,58 % на воздушно-сухой вес можно объяснить наличием на корне несколькими годичными чехлами.

Природные заросли кок-сагыза – это ценнейший фонд, из которого все время будет черпаться материал для индивидуального отбора, поэтому вполне рационально организовать заказник в районе природных зарослей кок-сагыза.

Кок–сагыз является высокополиморфным видом, что позволяет его использовать в селекционных программах. При индивидуальном отборе высокое содержание каучука в корнях кок-сагыза (10-14 %) наследуется.

В настоящее время кок-сагыз является важным каучуконосом, благодаря следующим своим особенностям: 1) высокому процентному содержанию каучука и выгодному его расположению, 2) цветению и плодоношению в первом году жизни,3) высокому качеству каучука. Полиморфизм кок-сагыза позволяет рассчитывать на отбор наиболее каучуконосных и наиболее скороспелых форм данного растения.

Ключевые слова: кок-сагыз, каучук, млечные сосуды.

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