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**Biochemical properties of seeds  
for domestic and international  
common bean accessions**

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**Шығу тегі жергілікті және  
шетелдік үрмебұршақ  
дәндерінің биохимиялық  
қасиеттері**

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**Биохимические свойства  
семян фасоли обыкновенной  
местного и зарубежного  
происхождения**

Beans are considered as the major resource of vegetable protein among plants. Beans are enriched by vitamins, minerals, flavanoids, fiber, and are also appropriate for cropping under the steppe as mountain conditions. Under arid conditions beans are regarded as useful tool for exploring those areas which are unsuitable for obtaining steady annual harvests. This paper summarizes the data on the introduction and breeding of a range of common bean varieties representing local and foreign specimens. It overviews the data on biochemical comparison of different bean varieties, and amino acids composition of the seeds.

Modern beans breeding is not supported by relevant physiological and biochemical investigations which would allow to evidence in favour of the impact of changing plant morphogenetic traits on biochemical characters, physiological functions, seed productivity, grain quality and plant adaptiveness to be inherited by the following generations.

**Key words:** beans, bean varieties, introduction, biochemical compounds, productivity, adaptability, breeding.

Бұршақты дақылдар барлық өсімдіктердің ішінде ақуызға ең бай болып саналады. Бұл дақылдарда дәрумендер, минералдар, флавоноидтер, өсімдік талшықтары мол және олар жазықта да таулы жерлерде де өсе береді. Құрғақшылық кезінде бұршақты дақылдар жыл сайын тұрақты мөлшерде алынатын өнімдер қатарына жатады. Бұл мақала үрмебұршақтың жергілікті және халықаралық жана сұрыптарын жерсіндіру мен өсіру туралы мәліметтерді жинақтайды. Мақалада үрмебұршақты биохимиялық салыстыру талқыланды, сонымен қатар тұқымдардың аминқышқылды құрамы қаралады. Қазіргі селекцияда бұршақ тұқымдастарға физиология-биохимиялық зерттеулерде қолдау нашар көрсетіліп жүр; бұл зерттеулер морфогенетикалық белгілердің биохимиялық өзгерістерге, физиологиялық ерекшеліктерге өсімдіктердің бейімделуіне, тұқымдардың өнімділігіне және сапасына, тұқымдарға әсер етеді.

**Түйін сөздер:** үрмебұршақ, үрмебұршақтың сорт үлгілері, биохимиялық қосылыстар, өнімділік, бейімделушілік, көбею.

Бобовые культуры являются чемпионом среди растений как основной источник растительного белка. Эти культуры обогащены витаминами, минеральными элементами, флавоноидами, растительным волокном и универсальны для возделывания в степной и горной зонах. В засушливых условиях бобовые рассматриваются как подходящие культуры для анализа спорных зон на предмет получения стабильных и ежегодных урожаев. Данная статья суммирует данные по интродукции и получению новых сортов форм фасоли, представляющих международные и местные сортообразцы. В статье обсуждаются данные по биохимическому сравнению сортообразцов фасоли, аминокислотному составу семян.

Современная селекция бобов слабо поддерживается физиолого-биохимическими исследованиями, которые указывают на влияние изменяющихся морфогенетических признаков на биохимические свойства, физиологические свойства, адаптивность растений, продуктивность и качество семян, наследуемые следующими поколениями.

**Ключевые слова:** фасоль, сортообразцы фасоли, биохимические соединения, продуктивность, адаптируемость, размножение.

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## **BIOCHEMICAL PROPERTIES OF SEEDS FOR DOMESTIC AND INTERNATIONAL COMMON BEAN ACCESSIONS**

Bean seeds and pods are known for their high palatability standards [1,2]. Beans contain proteins (17-32%, which is higher than the amount of protein in meat (20-22%), and fish (18-19%), carbohydrates (mainly starch, 55%), fats (1.8%), fiber, minerals (zinc, copper, potassium, iodine, iron, sulfur, magnesium) and vitamins (A, C, B1, B2, B6, E, and PP) [3-6].

Due to chemical composition, beans reveal strongly positive effect on immune and nervous systems, increase body resistance to viral and microbial invasions, promote wound healing, regulate metabolism, improve hematopoietic functions, remove gallbladder and kidneys stones, reduce liver's inflammation, make an impact on the activities of alimentary and urinary tracts. Besides, beans are recommended to defeat bronchial diseases, rheumatism, and intestinal infections, due to abundant antioxidants, iron, vitamin B6, and starch. The composition of white beans includes magnesium, fiber and folic acid. Their shortage may cause megaloblastic anaemia. Beans are often cultivated jointly with corn, potatoes and melons. As the crop and nitrogen-fixing species beans can be rotated to substitute cereals and root crops.

According to beans polymorphism, they have an exceptionally wide range of cultivation. Some varieties and forms indicate a lot of differences in vegetable and reproductive growth, as environmental characteristics. Studying such characteristics is considered to be necessary for further development of science-based farming techniques, which are supposed to be specific for diverse forms, varieties and areas. For this purpose the global gene pool of beans should be extensively explored. It is particularly important to get information on polymorphism of existing bean varieties and lines [7].

The grain legumes also play important role in improving soil fertility. Due to the symbiosis with nitrogen-fixing bacteria, they are able to seize free nitrogen from the air to accumulate it in roots and crop residues in range of 50-100 kg or even more per hectare [8]. Apart from the food, beans may be used as the source of citric acid, green manure, animal feed and heirloom plants [9].

Despite numerous beans benefits as their increased demand in the market, this vegetable crop is still not considered as conventional for our country.

Present-day bean production in Kazakhstan is complied mainly with imported seeds, raw and canned beans from CIS and foreign countries. Meanwhile, southeast regions of this country are extremely favourable for the cropping of high-protein bean varieties.

Modern beans breeding is not supported by relevant physiological and biochemical investigations which would allow to evidence in favour of the impact of changing plant morphogenetic traits on biochemical characters, physiological functions, seed productivity, grain quality and plant adaptiveness to be inherited by the following generations.

The aim of current study is to generate high-protein lines of common bean, put forward their qualitative characteristic based on bean breeding and extensive bean introduction.

### Materials and methods

Current study of research subject is based on «The Guidelines for Studying Collection of the Grain Legumes» and «The Classifier of *Phaseolus vulgaris* L. (Common bean)» [10], [11].

Seeds (11 specimens in the steppe zone, at «The Zhanga Talap Agrobiocenter», 29 specimens in the mountain (footfill) region, at the Institute of Botany and Phytointroduction, 9 specimens in the mountain region, «The Almarasan Canyon») were planted on plots (2 x 10 square meters). Double-row planting with wide row spacings (40 cm x 60 cm) was applied. Harvesting was carried out manually. In addition to the main collection of the mountain region, 6 samples of vegetable and heirloom varieties of French breeding were tested for the first time.

Cv. «Aktatti» known to be widespread in Almaty Region was used as a standard. Collection specimens were planted twice.

Phytochemical screening of beans samples, detection and identification of polyphenolic compounds of local and other samples was performed by Folin–Ciocalteu [12].

Quantitative detection of flavanoids was determined by the complex-forming reaction in presence of 1% alcohol solution of the aluminum chloride.

Total content of flavonoids was estimated based on calculating the quantity of rutin (vitamin P), whereas total content of phenolic compounds based on the amount of gallic acid (3,4,5-trihydroxybenzoic acid). The calculation was conducted by using the following formula:

$$X = A_x \times W \times W_2 / E_{1\%}^{1\text{cm}} \times m \times V_a,$$

where

$A_x$ , optical density of sample solution;

$W$  and  $W_2$ , dilutions, ml;

$E_{1\%}^{1\text{cm}}$  – specific absorption rate of a standard rutin solution;

$m$ , mass of seed sample, g;

$V_a$ , aliquot volume, ml.

### Results and discussion

To create the university collection of high-protein bush beans varieties, lines and accessions were picked out for further planting.

Common bean, *Phaseolus* L. has numerous varieties which are subdivided into two large groups: American beans and Asian beans. Whereas the first group is known for possessing large seeds, and less frequently small seeds, the second group is referred to have predominantly miniature, small seeds. Four American bean species are considered to be significant for our conditions: common bean (kidney bean, *Ph. vulgaris* Savi L.), lima bean (*Ph. lunatus* L.), runner bean (*Ph. coccineus* Willd.) and tepari (*Ph. acutifolius* Gray).

One of the Asian species displaying great importance for cropping in Kazakhstan is *Ph. aureus* Piperu, or golden bean (mung). It is cropped in Central Asia and Transcaucasian states for gain and green fertilizers.

In current research we have used American varieties including cvs «Red Goya», «Pinto», «Camellia», «Lima», then «Turkish beans», and Asian varieties including purple pole beans, cv. «Violet Maleo», cvs «Iranian», «Nut», «Dermason». There have been also some varieties from Polish («Bomba», «Igolinsky»), Russian («Biichanka», «Zhuravushka», «Fatima»), and locally bred cvs («Aktatti», «Nazym» and «Talgat» as other lines and local specimens).

Apart from this, 5 new French varieties were introduced and 6 French varieties were examined in «Almarasan Canyon» and on plots of the Institute of Botany and Phytointroduction. It is shown that cvs «Argus», «Mystery», «Dream of Venice» and «Triumph of the Farcy Town» have displayed high productivity. It is planned to have this seed material propagated under the steppe zone at the «Zhanga Talap Agrobiocenter».

To record field experiments and land specimens we have used essential software registered as «Planting Manager» [13].

Duration of the vegetation period is a significant factor for determining the opportunity to cultivate

or induce the beans in the region. Obviously, it is also one of the most important issues for the breeding. Based on research of the first vegetation season and its duration ranging from 80 to 140 days, bean samples were subdivided into early-ripening, average-ripening and late-ripening beans [14].

Groups of samples with different duration of vegetation could be characterized by specific variability of this character.

If early-ripening samples are less variable (2.5 – 5.9%), mid-ripening samples indicate growing variability reaching 5.7 – 6.5%. Because of minor number of late-ripening samples, this index for that case was neglected.

Out of 44 bean samples of different geographical region, more than a half was shown to belong to the average-ripening group (86-95 days), whereas the rest would be represented

by early-ripening forms with the exception of a single late-ripening variety.

Transition time from germination to the seedlings was established to depend on growing conditions in the steppe and mountain zones, and specific varietal traits. As indicated earlier [14], the period «germination – seedlings» for different types of common bean ranges from 25-40 days for early-ripening, and 30-60 days for average-ripening, to 33-70 days for late-ripening beans.

Technical maturity has been found to get reached in 90-105 days, what meant lasting 10-15 days longer than normal season of vegetation under local conditions.

Six local and foreign accessions have been subject to high-performance liquid chromatography, or HPLC to clarify amino acid composition (see Table 1).

**Table 1** – Amino acids composition of common bean seeds ( mg/100g)

Amino acids	Aktatti	Djungarskaya	Zhuravushka	IFGBR- 48	Camellia	Karakoz
Alanine	1405	1144	1025	1248	928	1352
Glycine	644	320	258	526	286	608
Leucine	420	378	425	425	404	480
Isoleucine	390	265	304	384	295	425
Valine	304	205	210	328	220	356
Glutamate	3980	2213	2082	3245	2147	3828
Threonine	462	214	192	448	218	483
Proline	1273	762	705	1064	694	1256
Methionine	335	118	130	290	142	350
Serine	628	416	378	702	415	780
Aspartate	2806	1045	1210	1948	1148	2344
Cysteine	55	18	25	42	24	62
Hydroxyproline	6	3	2	5	2	7
Phenylalanine	692	282	303	556	312	680
Tyrosine	729	304	342	608	356	735
Histidine	588	298	315	526	285	554
Ornithine	5	4	3	4	3	6
Arginine	738	587	538	640	515	715
Lysine	410	368	325	315	286	370
Tryptophan	278	120	112	226	98	268

As seen from the Table 1, the major fractions have occurred to be glutamatic (3980-2082 mg / 100 g) and aspartic acids (2806-1045 mg / 100 g), alanine (1405-928 mg / 100 g) and proline (1273-694 mg / 100 g). Noteworthy, domestic lines have turned out to surpass

external analogues by more than 91% by the glutamate content, more than 2.4 times by the aspartate content, more than 51% by alanine and 83% by proline.

Besides these abundantly presented glucogenic amino acids, it has been noticed that the ketogenic

amino acids (leucine, lysine and tryptophan) would be left in much lower concentrations, what allows to recommending related varieties for manufacturing diabetic products due to a minor risk of forming the ketone bodies.

The content of essential amino acids has been registered to be in range of 27.5-29.8%. Lysine, threonine and serine are biological substances enhancing the growth of human and animals. Interestingly, local lines «Aktatti» and «Karakoz» were shown to contain the greatest amount of sulfur-containing amino acids, methionine and cysteine, which level would be

maintained in seeds of these lines in amounts varying from 335 to 350 mg / 100 g and from 55 to 62 mg / 100 g, respectively. In addition, the line «Aktatti» has appeared to be enriched by lysine (410 mg / 100 g).

Therefore, it is confirmed that the protein content is dependent of the climatic changes, breeding technologies, soil characteristics and genotypic classification of the variety or line.

Studied accessions, varieties and lines could be classified by an Osborne classification presenting bulk of proteins as globulins (phaseolin, 60-90%) and albumins (10-20%) (see Table 2).

**Table 2** – Composition of essential amino acids (mg/100g) in bean seeds

Essential amino acids	Aktatti	Djungarskaya	Zhuravushka	IFGBR- 48	Camellia	Karakoz
Leucine	420	378	425	425	404	480
Isoleucine	390	265	304	384	295	425
Valine	304	205	210	328	220	356
Threonine	462	214	192	448	218	483
Methionine	335	118	130	290	142	350
Phenylalanine	692	282	303	556	312	680
Histidine	588	298	315	526	285	554
Lysine	410	368	325	315	286	370
Tryptophan	278	120	112	226	98	268
Total amount	3879	2248	2316	3498	2260	3966

Phytochemical composition of some local and foreign varieties and lines of common bean including «Aktatti», «Djungarskaya», «Camellia», «Nazym», «Red Goya» (seeds), «Talgat» (seeds and empty pods) and some others has been examined. Biologically active substances (BAS) detection has been carried out by using qualitative reactions and chromatography tools. This seems to be necessary as the pharmacologists keep seeking for specific sources of flavonoids, isoflavones and phenolic compounds. In order to have completed the formal lists of (BAS) by common bean, some reliable methods of quantification for the compounds forementioned are required.

In course of the study it has been shown that bean specimens with different geographical origin (Kazakhstan, USA and Russia) would be varying also in the content of flavonoids. So, line «Talgat» (Kazakhstan) and cv. «Red Goya» (USA) have appeared to lead by total amount of flavonoids (1.49 and 1.22 mg/g of dry weight, respectively), while cv. «Red Goya» (USA) and cv. «Ufimskaya» (Rus-

sia) would occur ahead of resting varieties and lines by total quantities of phenolic compounds (2.46 и 3.06 mg/g of dry weight, respectively). It has been also indicated that cv. «Zhuravushka» (Russia) could be implied as a negative standard for the flavonoids content, because this BAS fraction has not been virtually detected, though this variety contained phenolic compounds (1.93 mg/g of dry weight), as it was shown earlier [14].

Domestic line «Talgat» has been determined to be one of the most prospective forms by substantial prevalence of the overall flavonoids fraction.

It is clear from the data presented above that parental combinations for the local gene pool of common bean may be chosen in consent with phytochemical analysis of the collection in hand. Newly generated domestic lines have been shown to possess a high phytochemical potential.

Based on this study, major samples have been shown to occur highly productive, early-ripening and adaptive to the steppe and arid zones even under irregular watering. Yield of cv. «Igolinska»

has been shown to be reduced due to fungal disease. Structural analysis of varieties and lines grown in the steppe zone has determined the most prospective and adaptive cvs («Zhuravushka», «Camellia», «Aktatti», «Biichanka» and others). It has been shown that local line «Aktatti», along with some foreign varieties, would possess a powerful root system. This group of samples would be suggested for phytoremediation aims in the steppe zones [14].

Newly generated common bean lines should ideally combine high seed productivity, stability and highly efficient sets of biochemical and

phytochemical characters. However, it is possible to determine a single character of a prospective sample, since varieties and lines might possess optimal combinations of essential amino acids or phenolic compounds leaving behind such a crucial trait as plant productivity. Oppositely, highly productive varieties and lines could be quite poor in amino acid or polyphenol compositions. This versatile nature of common bean and its specific development allows us to use this vegetable crop for different purposes encompassing food and feedstuff production, pharmacology, phytoremediation, biotechnology and landscape design.

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