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THE PLANT HALF PRODUCTS FOR FORTIFICATION OF FOODSTUFFS

Abstract. *The subjects for researching are the green parts (tops) of beets, ramsons, nettle, garlic, pea husk, and onion skin. We confirmed the high content of indispensable amino acids – 87 to 283 mg per 100 g of leucine; 72 to 205 mg per 100 g of lysine; 504 to 1375 mg per 100 g in total. Dispensable amino acids in maximal amount are represented by glycine (83 to 377 mg per 100 g), alanine (87 to 251 mg per 100 g). Proteins in researched materials are outstanding with high grade of proteolysis (28.61 % for garlic; 28.81 % for nettle; 29.37 % for sugar beet), which slightly differs from the control index (milk proteins, 30.01 %).*

Taking green mass for a base to create the biologically active additives and polyfunctional ingredients is grounded scientifically, expedient technologically, and profitable economically. We have recommended using the green mass of plants for enrichment of any food bases in production of foodstuffs for both domestic and foreign markets.

Keywords*: fortified foods, biologically active components, functional properties*.

Widening the production of food protein and formation of its structure are the most important and difficult tasks for common and healthy nutrition. Constantly deepening deficit of food protein is conditioning the searches for its new sources, including those non-traditional.

The attempts to obtain proteinaceous concentrates out of tops of plants were accomplished simultaneously in the former Soviet Union and England in 1942. The first publication about leaf protein appeared in 1773 although the term ‘protein’ itself had been firstly proposed by Dutch chemist I. Mulder in 1838 (Peary, 1980).

Nowadays, there are studied only a few sorts of cultivated plants suitable for obtaining proteinaceous concentrates. These are legumes, alfalfa, rice, rape, clover, green peas. The prominent industrially developed countries have established the powerful agro industrial enterprises dealing with production of food proteins from plant raw materials (dried wheat gluten, high-concentrated forms of protein from soy, wheat and peas) at the end of the 20th century (Polumbryk, 2011). Today the total annual volume of high-concentrated protein production makes up circa 400…500 thousands of tons.

Involving traditional and novelty plant cultures into the sphere of production of protein and protein concentrates would provide solving of an array of social and economical problems, including:

- significant liquidation of food protein deficit, which would foresee both gaining its level in diets and improvement of protein quality;
- organization of industrial production of foodstuffs with definite protein composition, first of all those related to category of healthy food;
- production of high-quality, safe and effective foodstuffs on the base of optimal combination of proteins of both plant and animal origin, which would condition the proper nutritional value and its functional properties (Simakhina & Naumenko, 2020).

The following factors condition the choice of the new raw sources of protein:

- the quantitative and qualitative composition of protein complex;
- functional properties of proteins;
- biological value of proteins;
- the possible volumes of raw harvesting and laying-in (in separate regions and throughout the country);

- technological capacity of raw and its liability to procession on enterprises with different levels of productivity;
- the possibility to obtain several valuable half products with various functional action out of one certain kind of raw;
- maximal compatibility of components from proteinaceous green mass with nutrients of food environments exposed to enrichment;
- shelf-life conditions;
- the cost of proteinaceous half products, regarding their biological value and economic efficiency of an enterprise.

The majority of researches in the field of protein technologies is oriented at obtaining of either high-concentrated proteins (concentrates, isolates, proteinates) or chemically modified, including composites *protein-polysaccharide, protein-lipid* etc.

As for the authors of this article, the more expedient method is the wasteless procession of plant raw materials with further obtaining of proteinaceous concentrates. Those may differ by their rich nutrient composition, first of all – by the optimal natural correlation between proteins and other components of raw (pectin substances and other polysaccharides, lipids and vitamins); thanks to this, the efficiency and functionality of proteins will be enhanced. This technology would become more efficient from economic point of view as well, because it can eliminate the expensive and complicated processes of proteins' purification (in production of concentrates and isolates), their etherification and structuring.

Therefore, the objectives of this article are to prove scientifically and to confirm experimentally the expedience of using the tops of various plants.

The main tasks of the research are to study the amino acid content and biological value of tops of plants, and also to define the grade of proteolysis of proteins from researched materials in comparison with control substance (milk protein).

We chose the tops of the following plants for researches: sugar beet; garlic; pea husk; nettle; ramsons; garlic; onion skin. It is well-known that green plants contain 1.5 to 3.5 % of protein on the average; about 85 % of it is concentrated in leaf cells. Leaf protein is represented mostly with two types. First are cytoplasm proteins (ca

30 % of the total amount of protein, with molecular mass of 30…50 kD) contained in the solution and free of pigments. Second are insoluble colloid-disperse proteins with molecular mass of about 100 kD, which are constrained to chloroplasts and compose about 35 % of total amount of protein.

Young tender tops of sugar beets, garlic, ramsons and nettle were collected randomly from the wild and farmlands in Kyiv region, Ukraine. The samples were identified by a Taxonomist. Several plants of each species were combined to get representative samples. The samples were washed with distilled water, cut into small pieces, air dried (away from sunlight) and ground into fine powder using porcelain mortar and pestle.

The well-known ways to process the plant raw containing the biologically active substances are drying with further disintegration and, if necessary, extraction; thus, the plant half products in the shape of dried slices, particles with defined measure, or small-disperse powders are used in food industry in topmost grade (Simakhina, Huts & Solodko, 2017).

The authors of this article used the standard physical and chemical methods of estimating the plant raw.

The amino acid composition in tops of plants was defined by ion-changing chromatography (Spackman, 1988). The essence of this method is to hydrolyze proteins from the sample to amino acids and then to identify them by the method of high-effective liquid chromatography on the LC-5 device (produced by Shimazu). The dry sample had been hydrolyzed with a 6-n solution of hydrochloric acid in the temperature of (108 ± 2) Celsius degrees during 24 hours (the method was described in Magomya, 2014).

The tops of noticed plants were previously cleaned and inspected. Afterwards, they were disintegrated and their general chemical content was investigated. The obtained results are shown in Table 1.

Table 1

Chemical composition of tops of proteinaceous plants

Indicators	The raw material					
	Sugar beet	Garlic	Pea husk	Nettle	Ramsons	Onion skin
Dry substances, %	13.26	10.61	9.8	11.86	10.90	8.34
Protein, %	3.25	2.96	4.71	2.61	2.18	1.93
Lipid, %	0.67	1.32	0.83	0.49	0.02	0.03
Carbohydrates, %	6.22	5.65	5.04	5.72	5.97	4.76
Ashes, %	2.23	1.88	1.77	1.41	1.35	0.88

The analysis of the obtained data shows the following facts.

The amount of protein in dry substances allowed arranging the researched objects in the following order: sugar beet (24.5 %), dioecious nettle (22.0 %), ramsons (20.0 %).

Our researches have shown that all of the studied objects contain the significant amount of carbohydrates. This indicator is about 55 % of general amount of dry substances in ramsons; 48.2 % in nettle; 47 % in sugar beet.

Garlic is the richest in lipids (1.32 % of general amount of dry substances); the poorest one is ramsons leaves (0.18 %).

Dependently on the amount of ashes in dry substance, the researched objects have been arranged the following: sugar beet (16.8 %), ramsons (12.4 %), and nettle (ca 12 %).

Table 2 shows the content of indispensable amino acids in researched plants.

Table 2

The content of indispensable amino acids in researched plants

Amino acids	The amount, mg / 100 g					
	Sugar beet	Garlic	Pea husk	Nettle	Ramsons	Onion skin

Isoleucine	125	113	99	110	143	38
Leucine	283	280	269	155	87	97
Lysine	205	194	188	145	98	72
Phenylalanine + tyrosine	290	225	221	178	135	108
Methionine + cysteine	113	105	98	84	76	20
Tryptophan	42	39	40	41	38	45
Threonine	151	127	125	125	92	49
Valine	166	153	150	133	93	75
Total	1375	1236	1190	971	762	504

The necessity of using the products made of the researched raw materials may be well apprehended on the example of lysine.

As it is well-known, lysine is an essential (indispensable) amino acid necessary for human health; yet, the body cannot synthesize it itself. A human has to get lysine from food or supplements.

Amino acids, particularly lysine, are building blocks for proteins. Lysine is important for proper growth, which is actual now in Ukraine considering the bad ecological situation; and it also plays essential role in the production of carnitine (a nutrient responsible for converting fatty acids into energy and helping lower cholesterol; there are used worldwide two well-known preparations of carnitine, L-Carnitine and Cardonate to control body weight).

Lysine appears to help the body absorb calcium and form collagen. Both of these factors are crucially important for functioning of skeleton, muscles and so on (See University 2014).

The index of lysine amount in researched plant is the highest for sugar beet (205 mg / 100 g), garlic (194 mg / 100 g), and pea husk (188 mg / 100 g).

Table 3 contains the results of researching the dispensable amino acid content in mentioned plants.

Table 3

The content of dispensable amino acids in researched plants

Amino acids	The amount, mg / 100 g					
	Sugar beet	Garlic	Pea husk	Nettle	Ramsons	Onion skin
Alanine	251	187	236	115	87	94
Arginine	172	197	185	235	207	86
Aspartic acid	250	243	264	90	148	138
Hystidine	78	75	67	123	135	43
Glutamine	248	198	221	411	141	124
Glycine	377	334	325	83	183	96
Proline	220	199	138	80	104	63
Serine	171	146	124	65	107	42
Total	1767	1579	1560	1202	1112	592

As one of the most important among dispensable acids, glutamine is the most abundant in human body, and the body can synthesize enough glutamine for its needs. However, during times of extreme physical and psychic stress (especially for Ukrainian armed forces who take part in anti-terroristic operation in East regions), the body may need more glutamine than it can make.

Certain medical conditions, including injuries, surgery, infections, and prolonged stress, may lower the level of glutamine; in these cases, taking a glutamine-containing supplement may be very helpful (Barros et al., 2011). The products made of raw materials researched in this article (especially nettle – 411 mg / 100 g, sugar beets – 248 mg / 100 g, and garlic – 198 mg / 100 g) may complete the body needs in glutamine (and other dispensable amino acids, too).

The further perspective of using the foodstuffs that include the studied raw supplements is their implementation into diets for military personnel.

Both of the tables given above represent the general amino acid composition of plant raw and half-processed (pea husk, onion skin) materials. The data show that the entire researched raw contains 18 amino acids including all of those indispensable. It is to mark that the content of indispensable amino acids relatively to the general amino acid amount is about 38…45 per cent, which evidences the significantly balanced amino acid composition in all of the studied objects.

The obtained data show the biological value of proteins in researched green mass of plants. It is well-known that the correlations between dispensable and indispensable amino acids play the crucial role in formation of optimal conditions for catabolic processes. There was experimentally confirmed that the maximal biological effect of food proteins may be reached with the general nitrogen amount of 42 % of indispensable; the other 58 % may be taken from the dispensable amino acids.

The important characteristic for proteins is their grade of digestion by proteolythic enzymes in the alimentary canal. The results of researching this parameter are given in table 4.

These results showed that digestion of proteins extracted from tops of sugar beets reached 78…82 per cent and therefore varies very little from the analogical indices for control proteins (milk proteins) and slightly exceeds those for nettle and garlic.

Generally, proteins of all the researched materials in entering the alimentary canal would be easily dissociated into amino acids under the impact of proteolythic enzymes and be absorbed into blood wholly.

Table 4

The amount of hydrolyzed *in vitro* proteins in researched materials, per cent

Material	Proteolysis stage							
	Pepsin	σ±	Tripsin	σ±	Peptidase	σ±	General proteolysis	σ±
Milk								

proteins (control)	3.50	0.76	11.24	0.39	15.27	0.34	30.01	1.46
Green mass of sugar beet	3.14	0.34	11.19	1.44	15.04	0.19	29.37	0.94
Green mass of nettle	1.22	0.14	11.07	0.56	16.52	2.32	28.81	1.16
Green mass of garlic	2.65	0.82	11.04	0.48	14.92	0.11	28.61	0.32

In enriching the diets with amino acids, it is necessary to represent them in optimal correlations. Either deficit or surplus of a certain amino acid may cause the misbalance, or a violation of amino acid balance. The symptoms of misbalance can be exposed more apparently in low-protein diet with a small amount of indispensable amino acids.

The data about the biochemical composition of separate plant samples show their wide possibilities in use for human nutrition and production of new foodstuffs. Generally, the plant raw materials chosen as the objects for researches are outstanding due to comparatively high content of protein (20…25 per cent of the whole amount of dry substances).

Moreover, the nutritional value of protein extracted from the studied plants is pretty high and stands close to animal origin proteins. During the researches, we had found out that the proteins of green mass of various beets have got the highest biological value. Henceforth, we may make a conclusion that the proteins from tops of plants, as being digested in an alimentary canal, would be dissociated by proteolythic enzymes to amino acids and then absorbed into blood wholly.

The further researches foresee the production of dry proteinaceous half-products with wide array of extremely precious biologically active substances. They are chlorophyll and the products of its dissociation; ascorbic acid; carotenoid group, first of all β-carotene. These products would become the most important for the population strata, which take the small doses of green leafy vegetables and suffer from the vitamin A deficit.

Therefore, the experimental data obtained during our research show that green mass of plants is a very rich source of a complex of biologically active substances, which would allow obtaining the new foodstuff with increased biological value. Taking plant tops for a base to create the biologically active additives and polyfunctional ingredients is grounded scientifically, expedient technologically, and profitable economically; henceforth, the expected products from green mass of plants would have a great demand on both domestic and foreign markets.

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