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Study of Biotechnological Potential of Blood Agricultural Animals and Poultry for The Development of New Balanced Food Products.

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ABSTRACT

This article considers the biotechnological potential of blood of farm animals as a promising raw material for food production. The estimation of chemical composition, biological value of blood and its separate components is given. A conclusion is made about the quality of the protein, the functional properties of the dispersed systems formed, and a comparative evaluation of blood as a source of the organic form of iron is also given.
Keywords: hemoglobin, blood, food protein, anti-anemic products.

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INTRODUCTION

The blood of farm animals and the products of its processing are a unique source of nutrient and biological active substances, based on the content of organic iron and proteins, quantitatively and qualitatively adequate to the proteins of the muscle tissue of animal organisms. Blood and its fractions are traditionally used in the production of meat and medical-prophylactic products, medicines, feed. However, the biotechnological potential of blood and its fractions is not fully realized due to insufficient scientific substantiation of new technical solutions and correction of traditional technologies to maximize the involvement of food and feed products, including new forms with high nutritional value and storage, including account for the production and use of concentrated forms of plasma and shaped elements [1, 4].

With the revival of the processing industries of the agro-industrial complex, an increase in the volume of slaughter of cattle and birds, a significant volume of blood accumulates for food purposes, which requires inclusion in the main production on the basis of modern approaches to increasing the resource potential of the industry, where edible emulsion plays an important role [5].

In-depth study of the composition and functional-technological properties of the protein complex of blood of agricultural animals and birds opens up new opportunities in creating technological innovations in increasing the resource potential of the meat and poultry processing industries for the production of nutrient-balanced and functional feed and food products. Obviously, new approaches and methods of using blood as a by-product of processing industries will significantly increase the yield of useful products from a unit of processed raw materials, create new assortment lines of food and feed products, reduce the biogenic hazards of production and ensure environmental protection through wastage [6, 7, 8].

Blood is the internal environment and the main communication system of the body. It is a viscous opaque liquid, a brackish taste, continuously circulating in a closed system of blood vessels and performing vital functions that maintain the integrity and functionality of living systems.

Morphologically, blood is one of the types of connective tissue of the body, it consists of a liquid intercellular substance - plasma and cells - of the elements: red blood cells, leukocytes, platelets that are rudimentary in nature and perform specific functions in the life of organisms.

The ratio of plasma to blood cells varies depending on the species of animals (Table 1).

Table 1: Mass fraction of blood fractions (%), depending on the species of animals

Type of livestock	Plasma	Formal elements
Cattle	67,4	32,6
Pigs	56,5	43,5
Cattle	72,0	28,0
Horses	60,2	39,8

The morphological composition of the blood of animals and birds is affected by a number of intravital factors: genetic features, content and feeding, productivity, speed of movement of animals (I.S. Tokin), growth rate (K.A. Anokhin), etc. This, apparently, causes some differences in the information on the morphological composition of the blood, presented in publications of different authors [16].

The blood of agricultural animals and the products of its processing are a unique source of essential and biological active substances, based on the content of organic iron and proteins, quantitatively and qualitatively adequate to proteins of muscle tissue and blood of animal organisms, including humans [14, 15].

Blood is a complex heterogeneous system, characterized by the presence of a number of important chemical components, including biologically active (organic iron, digestible proteins, enzymes, etc.). When living in the blood of animal organisms come various products of tissue metabolism, oxygen, as well as nutrients. Despite this, the general chemical composition of the blood within the species is normally constant and may differ in different species. The chemical composition of the blood is presented in Tables 2 and 3. It depends on the type, age, fatness, fattening and conditions of pre-slaughter maintenance of farm animals and poultry [12, 13].

Table 2: General chemical composition of blood farm animals

Blood component	Blood content, %			
	Cattle	Small cattle	Pigs	Horses
Water	80,9	82,1	79	74,9
Dry residue	19,1	17,9	21,0	25,1
including:				
common protein	17,3	16,4	18,9	23,6
Hemoglobin	10,3	9,3	14,2	16,7
Sugar	0,07	0,07	0,07	0,05
Cholesterol	0,19	0,14	0,04	0,03
Lecithin	0,24	0,22	0,23	0,29
Fat	0,057	0,094	0,109	0,06
fatty acid	-	0,049	0,047	-
Sodium	0,37	0,36	0,40	0,27
Potassium	0,04	0,04	0,23	0,27
iron oxide	0,035	0,035	0,05	0,057
Calcium	0,006	0,007	0,007	0,005
Magnesium	0,003	0,003	0,009	0,006
Chlorine	0,31	0,31	0,27	0,28
common phosphorus	0,04	0,04	0,20	0,04

Table 3: Chemical composition of blood of poultry

Type of poultry	Mass fraction of components , %				
	Water	Fat	Protein	Ash	Nitrogen-free substances
Broiler chickens	80,1	0,2	18,6	0,8	0,3
Chickens	78,2	0,0	20,0	1,0	0,4
Turkeys	80,3	0,3	18,2	1,0	0,4
Geese	77,9	0,4	20,3	1,0	0,4
Ducks	79,2	0,3	19,2	0,9	0,4

The data of the tables indicate that water and proteins are the prevailing chemical substances of the blood. From the physico-chemical point of view, blood is a colloidal solution, in which, in addition to the basic constituent - proteins, there are a number of other substances: mineral salts, carbohydrates, fatty substances, vitamins, pigments, enzymes, hormones and many other biologically active substances.

Along with protein substances, the composition of blood and its fractions includes non-protein nitrogenous and nitrogen-free substances, mineral compounds, pigments, vitamins, lipids.

Nitrous non-proteinaceous substances include urea, ammonia, amino acids, creatine, creatinine, uric acid, purines and other compounds. Non-toxic substances include mainly carbohydrates: glucose, fructose, glycogen, as well as lactic and pyruvic acids [10].

Mineral substances include sodium chloride, sodium sulfate, calcium phosphate, acid phosphate salts of potassium, sodium and others.

Pigments of blood include hemoglobin, bilirubin, bileverdine, lipochromes, lute in, urobilin. Lip chromes belong to the group of arytenoids, luteins are plant pigments. Thus, the red-yellow color of bovine blood serum is due to the presence of a significant amount of xanthophiles in it, and the yellow color of the serum of pigs is caused by the extremely low content of these enzymes in it.

Lipids are mainly represented by neutral fat and products of its decay, as well as lecithin, cephalin, cholesterol [6].

The composition of the blood also includes vitamins and hormones. Vitamins include thiamin (B1), riboflavin (B2), ascorbic acid (C), vitamins of group A, vitamins of group D, biotin (H), pantothenic acid (B3), tocopherol (E), vitamin K, cobalamin (B12) [7, 8].

From hormones in the blood insulin, adrenaline, hormones of the pituitary gland, from numerous enzymes: hydrolytic - amylase, splitting starch; lipase, which breaks down fats; as well as proteolytic enzymes.

So, we can state that in the functional-biological and functional-technological aspects, protein components play a crucial role, since the share of proteins in the blood accounts for about 18-21%. Blood proteins are well studied and information about them is presented in the scientific literature, but the data are often contradictory. The protein content of blood is practically the same as meat and contains only 10-15% more water. In this case, the uniform elements contain two-thirds of all blood proteins. It is of interest to consider generalized modern data on the structure and functions of individual proteins. Blood proteins of agricultural animals are represented by a number of peptides of different masses, the concentration of which depends on the species of animals.

According to O.V. Kriger [9], proteins of whole blood of horses are represented by eleven fractions, four of which have a high molecular weight: 855.00 kDa, which is 1.94% of the total number of proteins; with a mass of 590.00 kDa - 2.75%; weight 311,80 kDa -2.76%; with a mass of 209.43 kDa - 2.42%. The total amount of protein fractions of blood of pig -12, of which four can be attributed to high molecular weight: 855.00 kDa, which is 3.24%; with a mass of 590.00 kDa - 2.85%; weight 311,80 kDa - 5.76%; with a mass of 209.43 kDa - 2.92%.

Proteins of whole blood of cattle are represented by ten fractions, three of which are characterized by a high molecular weight: 850.23 kDa -3.24%; weight 311,80 kDa - 5.76%; with a mass of 209.03 kDa - 4.42%.

The blood of small cattle has four high-molecular fractions with a total number of 11: 850,23 kDa with a concentration of 2.94%; weight 592.20 - 3.96%; weight 311,80 kDa - 4.76%; with a mass of 209.03 kDa - 3.42%. The given data speak about the peculiarities of protein structure depending on the species, metabolic activity and duration of "life" of cellular structures, the ratio of venous and arterial blood

Modern data indicate that albumin, serum globulin, fibrinogen, and hemoglobin are the main high-molecular fractions of proteins of whole blood of animals and birds, the amino acid composition of which is individual and is presented below (Table 4).

Table 4: Amino acid content in animal blood proteins

AMINO ACID	CONTENT,% TO PROTEIN							
	FIBRINOGEN		HEMOGLOBIN		SERUM GLOBULIN		ALBUMIN	
	DATA FROM		DATA FROM		DATA FROM		DATA FROM	
	[2]	[3]	[2]	[3]	[2]	[3]	[2]	[3]
PHENYLALANINE	4,6	7,0	9,6	5,3	4,7	3,8	6,6	6,2
TRYPTOPHAN	3,5	3,5	2,0	1,2	2,8	2,3	0,7	0,6
ARGININE	6,7	6,7	3,5	2,4	5,8	5,2	5,9	6,2
HISTIDINE	2,3	2,3	8,5	2,9	2,1	3,5	4,0	3,8
LYSINE	9,0	9,0	10,0	7,5	6,3	6,2	12,8	12,4
METHIONINE	2,6	2,6	1,2	1,6	1,0	1,0	0,8	1,3
THREONINE	7,9	7,9	6,0	6,8	7,4	8,4	5,8	6,5
LEUCINE	7,1	14,3	14,9	16,6	9,5	18,7	12,3	13,7
ISOLEUCINE	5,0	5,0	0,0	1,6	2,0		2,6	2,9

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VALINE	3,9	3,9	11,0	9,1	9,7	5,5	5,9	0,5
ASPARTIC ACID	11,9	-	10,0	-	9,0	-	10,9	-
GLUTAMIC ACID	13,8		7,4		12,5		16,5	
CYSTINE + CYSTEINE	1,5		0,9		2,3		5,9	
TYROSINE	6,0		2,9		6,7		5,1	

Proteins of animal blood are full, with the exception of hemoglobin, in which there is no isoleucine, but according to other sources it is also full. Moreover, it should be noted that the content of certain amino acids in blood proteins and individual protein fractions varies widely, which is probably due to the species of animals, breed, sex, age, food ration, structural features and metabolic activity.

The amino acid composition of total proteinaceous substances of whole blood of agricultural animals is presented in Table 5.

Table 5: Amino acid composition of whole blood proteins of farm animals

AMINO ACIDS	CONTENT, G / 100 G OF PROTEIN IN THE BLOOD				
	[4]				[3]
	PIGS	CATTLE	HORSES	SMALL CATTLE	GENERALIZED BLOOD DATA
VALINE	7,5 ± 0,75	7,5 ± 0,75	7,9 ± 0,75	7,3 ± 0,75	6,41
ISOLEUCINE	1,8 ± 0,18	1,8 ± 0,18	1,8 ± 0,18	1,7 ± 0,18	1,28
LEUCINE	9,9 ± 0,99	10,9 ± 1,09	9,9 ± 0,99	9,9 ± 1,09	8,34
LYSINE	9,5 ± 0,95	8,5 ± 0,85	9,4 ± 0,95	8,5 ± 0,85	8,61
METHIONINE + CYSTINE	3,0 ± 0,3	2,0 ± 0,2	3,2 ± 0,3	2,0 ± 0,2	1,62
THREONINE	4,0 ± 0,4	3,0 ± 0,3	4,0 ± 0,4	3,0 ± 0,3	4,56
TRYPTOPHAN	1,5±0,15	1,3 ± 0,13	1,5 ± 0,15	1,2 ± 0,13	1,3
PHENYLALANINE + TYROSINE	8,9 ± 0,89	7,9 ± 0,79	9,9 ± 0,89	9,9 ± 0,79	8,45
ALANIN	8,5 ± 0,85	9,5 ± 0,95	8,5 ± 0,85	9,5 ± 0,95	7,47
ARGININE	4,5 ± 0,45	3,5 ± 0,35	4,5 ± 0,45	3,9 ± 0,35	5,84
ASPARTIC ACID	9,0 ± 0,9	11,0 ± 1,1	9,0 ± 0,9	10,0 ± 1,1	10,47
HISTIDINE	5,7 ± 0,57	3,7 ± 0,37	5,7 ± 0,57	3,7 ± 0,37	4,38
GLUTAMIC ACID	8,4 ± 0,84	8,9 ± 0,89	8,4 ± 0,84	8,1 ± 0,89	17,29
GLYCINE	4,6 ± 0,46	3,6 ± 0,36	3,6 ± 0,46	3,6 ± 0,36	4,76
OXYPROLINE	1,0 ± 0,1	2,0 ± 0,2	1,0 ± 0,1	2,1 ± 0,2	0,02
PROLINE	3,3 ± 0,33	4,3 ± 0,43	3,3 ± 0,33	4,3 ± 0,43	3,41
SERIN	8,9 ± 0,89	10,6 ± 1,06	7,9 ± 0,89	9,6 ± 1,06	4,87

As can be seen from the data in Table 6, the values differ, which requires the development of applied aspects of the evaluation of the amino acid composition in each specific case. Moreover, one cannot but note the greater content of valine, leucine, lysine, phenylalanine + tyrosine, alanine, aspartic acid and serine in the blood of each animal species, which is very important in assessing the biological value of blood and characterizing its biotechnological potential as a promising raw material for obtaining balanced fodder, whole milk substitutes, food products of therapeutic and prophylactic value. In addition, as noted by several researchers, it is possible to increase the biological efficiency of blood proteins by 10-30% by hydrolysis with chemical and biological methods, the resulting mixture of amino acids and peptides is most fully absorbed by the body and lacks the anaphylactic properties of the protein itself.

It is very useful in the practical use of fractions to take into account the characteristics of the chemical composition, and especially proteins. The soluble substances of blood plasma account for 9-10% of them, about 7% - proteins. The coefficient of plasma protein efficiency (CEB) is 2.14, which is close to that for casein.

Plasma of blood, which is a bioobject with unique polyfunctional properties, occupies a special place among sources of high-grade protein for the production of food, medicinal, fodder and technical products. This is due to its chemical composition and, above all, the properties of proteins. For the processing of blood of slaughter animals, the main fractions of plasma proteins are the most important: serum albumins, serum globulins and fibrinogen (Table 6).

Table 6: Ratio of protein fractions in blood plasma of animals

Protein fractions	Mass fraction in blood plasma, %		
	Cattle	small cattle	Pigs
Fibrinogen	0,60	0,46	0,65
Serum Albumin	3,61	3,83	4,42
Serum globulins	2,90	3,00	2,96

Globulins of blood plasma are a large group of proteins of different structure, which conditionally denote α-, β- and γ- globulins depending on their electrophoretic mobility, with many fractions γ- globulins are antibodies. For most serum globulins, a high carbohydrate content (up to 42%) is characteristic.

Enzymatic treatment of native plasma proteins with the preparation "Collagenase food" leads to the hydrolysis of a portion of high molecular weight proteins with a decrease in their concentration and molecular weight and the appearance in solution of a significant number of low molecular weight substances. At the same time, 70.6% of the total mass fraction of all protein fractions make up peptides, also increases the content of free essential amino acids 2 - 3 times and reducing substances 3 times, which positively affects the biological value of blood plasma (Table 7) [15].

Table 7: Comparative characteristics of the biological value of blood plasma and its hydrolyzate

Blood plasma:	Biological value, %	The coefficient of utility of the amino acid composition	The indicator of comparable redundancy	Limiting amino acid
by Fayvyshevsky [7]	11,62	0,28	91,31	Isoleucine
by Kulpina [8]	17,74	0,42	47,98	Isoleucine
by Zharinov [6]	45,70	0,55	28,82	Isoleucine
by Nikolaychik [5]	49,19	0,55	28,99	Methionine + cystine
hydrolyzed (by Nikolaychik) [5]	60,20	0,73	13,28	

The proteins of the blood plasma include enzymes. These include end ferments that perform regulatory functions (catalase, peroxidase, ceruplasmine, etc.), exoenzymes (thrombin, plasmin, etc.).

Nitrogen-containing extractives are always present in the plasma, among which intermediate and final products of nitrogen exchange (purine bases, peptides, amino acids, urea, uric acid, creative, ammonium salts, etc.). Residual nitrogen can serve as an indicator of the freshness of blood and blood products [8].

The carbohydrate fraction of the blood plasma contains the products of carbohydrate metabolism (glucose, fructose, lactic, pyretic and α-ketoglutaric acid).

Fat in the plasma is small; it is finely emulsified and well digested due to the presence of phospholipids. Lipids in plasma depend on food, animal species and fluctuate from 0.09 to 0.19%.

Plasma is also a good source of mineral salts, vitamins. The mineral composition of the plasma is quite diverse. It contains sodium, potassium, calcium, magnesium, iron, copper, chlorine, iodine, phosphorus and many other substances. The total content of minerals in animals of different species averages 0.9%.

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Phosphorus in the blood is in the form of various compounds: in the composition of lipids, in acid-soluble and inorganic compounds. The content of iron in plasma for industrial use is determined by the quality of its separation with shaped elements. If the hemolytic occurred during separation, the functional properties of plasma proteins deteriorate. In addition, an increase in triglyceride plasma content is also observed, which negatively affects the quality of the products.

Formed blood elements are a valuable bio resource of protein and digestible iron for obtaining a wide range of food products, including directed physiological action in anemia of various origins and severity.

Erythrocytes constitute the bulk of the formed elements: from 1/3 to 1/2 the volume of blood, which determines their chemical composition and the degree of compliance with the needs of the human body when used as components of food formulas.

The main protein of the element elements is hemoglobin, a complex protein that makes up the bulk of the red blood cells (30-41%), containing globin and the non protein part (prosthetic group) - heme, which is bound to the Fe + 2 ion.

In foods, iron is contained in two forms: in the form of divalent and ferric iron (heme iron) in meat products and in the form of ferric iron (non-haem iron) in plant foods. Table 8 presents comparative data on the content of heme iron in meat raw materials.

Table 8: Content of heme iron in meat raw materials

Meat raw materials	The content of heme iron,% of total iron	Form of heme iron
Beef	60	Myoglobin (90 %) + Hemoglobin (10 %)
Pork	45	Myoglobin (90 %) + Hemoglobin (10 %)
Mutton	55	Myoglobin (90 %) + Hemoglobin (10 %)
Liver	40	Hemoglobin
Blood	99	Hemoglobin
Poultry meat	55	Myoglobin (90 %) + Hemoglobin (10 %)

Among food sources of heme iron, the advantage of blood is obvious. The biological significance of iron in the body is very large, being a component of a living cell, it participates in many metabolic processes of the body, especially its role in providing tissue respiration processes. Enzymes containing iron, take part in the synthesis of thyroid hormones, the maintenance of immunity. The involvement of blood and uniform elements in the production of food products will significantly expand the well-known assortment of anti-anememic products by combining with meat and by-products of agricultural poultry, raw material sources of plant origin.

CONCLUSION

The level of nutrients in the blood of farm animals and poultry allows us to evaluate it as a promising source of protein and anti-anemic factors. It is known that the protein content of 10 kg of plasma is adequate 4 kg of beef or 5.6 kg of pork, or can replace the protein of 150 eggs. In addition, the nutritional value of the blood is increased by the enzymes, hormones, micro- and macro elements contained in it, etc. The coefficient of digestion of the blood proteins is 0.94-0.96, which is close to the proteins of the chicken egg. The content in the blood of the complex of all substances necessary for the normal functioning of the organism indicates the possibility of its use not only as a food raw material, but also a valuable source of raw materials for the production of therapeutic and prophylactic nutrition products, functional purpose and medical preparations.

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