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Kangaroo Meat as a Valuable Raw Material for Dietary Products

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Kangaroo meat has appeared on the meat and meat products markets of many countries in recent decades. It costs by as much as 30% lower than that of the traditional slaughter animals. Non availability of extensive and reliable information about the kangaroo meat quality and its properties causes doubts and distrust in the kangaroo-based meat products among customers. Kangaroo meat was analyzed for safety and quality to develop the ways of its efficient application. It was found that kangaroo meat was a safe raw material. It contains more than 23% of proteins and not more than 2.6% of fat, which considerably distinguishes it from beef. Kangaroo meat proteins are complete as the score of all essential amino acids in the kangaroo muscle tissue exceeds 100%. The index of the relative biological value of kangaroo meat is somewhat higher than that of the traditional meat raw material and amounts to 99%. Kangaroo meat lipids contain up to 12.8% of phospholipids, about 60.0% of unsaturated fatty acids, which are essential food factors for a human body. Kangaroo meat considerably exceeds the traditional kinds of meat in riboflavin, thiamine, potassium, phosphorus, iron and zinc content. Samples of cooked sausage and canned food were produced. Their beef weight fraction was substituted for kangaroo meat. Kangaroo meat -based ready-made products were characterized by super organoleptic properties, foreign flavours and smell were non available.

Key words: Kangaroo meat, Chemical composition, Energy value, Sausages, Canned food, Diet products.

Wild animal meat, including that of exotic ones, is considered to be ecologically clean and richer in various natural substances than that of traditional slaughter animals (Gutnik and Zaharov, 2005; Mikirtichev and Morozov, 2012; Ulickii, 2006; Ustinova and Lazutin, 2008; Chernukha et al., 2004). It is due to the fact that those animals live in the wild world and eat different plant food. However, non-traditional animals meat is set to the second rate auxiliary raw material.

Kangaroo meat has appeared on the meat and meat products markets of different countries in recent decades. It is characterized by high content of proteins and small amount of fat (Dubova and Kalinichenko, 2006; Tatulov et al., 2006; Collins, 2008; Sinclair et al., 1997). Kangaroo is a wild pouched mammal animal. It lives in Australia, on the islands of New Guinea, Tasmania, and Bismarck Archipelago. Its body length is about 160 cm, its weight amounts up to 70kg. Fresh kangaroo meat is of dark red colour, slight characteristic smell which is peculiar for wild animals meat. Cooked meat is characterized by pleasant taste and smell. Many health benefits of kangaroo meat application are due to its chemical composition peculiarities (Tatulov et al., 2006; Sinclair, 1997). When kangaroo meat is used for food the cholesterol level in the blood decreases and it results in decreasing the risk of cardiac

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diseases and metabolic disorders, which result in diabetes development. The application of meat raw material with low content of fat and cholesterol is of great practical importance for obtaining products of advanced processing. It can contribute to the diet improvement of different population groups.

Kangaroo meat has started to be supplied to the Russian market for industrial processing since 2005 in the form of cuts on bones or in the form of boneless parts after carving (Specifications, 2003). It was used for producing semi-smoked sausages of the following brands: salami "Vostochnaya", cervelat "Promorskiy", small sausages "Pikantniye" and sausage "Spasskaya" (Dubova and Kalinichenko, 2006). Kangaroo meat weight fraction was 26-65%. There were no customers claims as to the quality of sausage products supplemented with kangaroo meat.

Investigations of meat products market and assortment, and customer preferences analysis showed that kangaroo meat-based products cause doubts and distrust of customers in many cases (Tatulov et al., 2006; Ampt and Owens, 2008). This is likely to be due to the lack of extensive and reliable information about the kangaroo meat quality and its useful properties. However the efficiency of kangaroo meat application for the industrial processing is quite obvious. Animal resources are self-renewing. Their removal from the nature is the necessity for the territories where they live (Baumber et al., 2009; Crof, 2000). Wholesale price for kangaroo meat is by as much as 30% or even more than 30% lower than that of live-stock animals' meat.

Application of kangaroo meat in food products technology can contribute to decreasing the raw material shortage, product differentiation and new customer preferences formation as well as conferring dietetic and functional properties to meat products. Thereupon, the investigation of the kangaroo meat quality and safety, the development of its meat products new technologies, the evaluation of their food value and useful qualities are very challenging today.

The objective of this investigations was the examination of the food and biological value of kangaroo meat and its products.

Objects and investigation methods

Frozen kangaroo meat delivered to the Far Eastern region of Russia in accordance with the normative documentation (Specifications, 2003) was used for the investigations. Fig.1 shows the scheme of kangaroo cutting in the form of which meat is applied for the industrial processing.

Frozen meat of slaughter animals, such as reindeer meat, beef and calf and their meat products, was used for the food value comparative evaluation.

Safety indicators of meat raw material and of ready-made products were determined by standard methods in accordance with the requirements of the Customs Union Technical Regulations (N 034/2013 "On meat and meat products safety", N 021/2011 "On food products safety"). The content of toxic elements was defined by using atomic absorption spectrophotometer "Nippon Jarrel Ash AA-855 (Japan). Moisture, protein, fat and mineral substances content in meat raw material and meat products was defined by the recommended methods (Antipova et al., 2001; Folch et al., 1957). Amino acid composition of proteins was studied by using amino acid analyzer L 8800 ("Hitachi", Japan). The amount of phospholipids in animal meat lipids was defined by the recommended methods (Vaskovsky et al., 1975). Fatty acid composition was examined by using gas-liquid chromatograph "Shimadzu AA 6800" (Japan). Iron, phosphorus, zinc and other mineral elements content was determined by using atomic absorption spectrophotometer "Shimadzu AA 6800" (Japan). Water soluble vitamins content was defined by the method of high performance liquid chromatography using the device "Shimadzu CBM-20A Prominence". Biological value of meat raw material was determined by the method of accelerated biological assessment using ciliate *Tetrahymena pyriformis* as an indication object (Shul'gin et al., 2006).

RESULTS AND DISCUSSIONS

Frozen kangaroo bulk meat and slaughter animals meat examinations showed that the used meat raw material in its microbiological indicators of safety, in the content of heavy metals, antibiotics, radionuclides and pesticides satisfied the requirements of the Customs Union Technical Regulations N 034/20132013 "On meat and meat products safety", N 021/2011 "On food products

safety".

Kangaroo block meat differed in its appearance from other animals muscular tissues by its more intense dark colour. Other significant differences in organoleptic characteristics of the investigated samples of animal meat were not defined. More intense colour of kangaroo meat remained unchanged after cooking.

The examination of meat raw material showed (table 1) that kangaroo meat was characterized by higher content of proteins than meat of other slaughter animals. The content of fat in kangaroo meat doesn't exceed 3%, that is significantly lower than that in beef. General quantity of mineral substances in kangaroo meat exceeds this indicator in other kinds of meat raw material. The kangaroo meat energy value stands intermediate between reindeer and calf, which are widely accepted as dietetic meat raw material and are used for obtaining healthful and dietary products (Brenc and Burlimova, 1988).

Product biological value is known to be characterized by the protein component quality and directly the protein amino acid composition (Skurihin and Nechaev, 1991). Essential amino acids, which are not synthesized at all or

Table 1. The overall chemical composition and energy content of kangaroo meat and other animal

Components	Meat			
	Kangaroo mea	Venison	Beef	Veal
Water, %	72,8±2,3	73,6±2,1	64,2±1,8	76,8±2,2
Protein, %	23,2±0,9	20,3±0,6	19,0±0,7	19,9±0,5
Fat, %	2,6±0,4	4,8±0,5	15,8±1,1	2,2±0,4
Minerals, %	1,4±0,1	1,3±0,1	1,0±0,06	1,1±0,07
Energy value, kcal	116,2±7,2	124,4±6,9	218,2±11,0	99,4±6,6

Table 2 . The amino acid composition of proteins kangaroo meat and farm animals

Amino acids	WHO/ FAO Scale	Meat							
		Kangaroo Mea		Venison		Beef		Veal	
		A	C	A	C	A	C	A	C
Leucine	7,0	8,2	117,1	7,2	102,9	8,4	120,0	7,3	104,3
Phenylalanine + tyrosine	6,0	7,5	125,0	6,9	115,0	7,2	120,0	6,7	111,6
Lysine	5,5	7,5	136,4	7,9	143,6	8,1	147,3	8,1	147,2
Valine	5,0	5,4	108,0	5,0	100,0	5,7	114,0	5,6	112,0
Isoleucine	4,0	5,7	142,5	4,0	100,0	5,1	127,5	4,9	122,5
Threonine	4,0	4,3	107,5	4,1	102,5	4,0	100,0	4,2	105,0
Methionine + cysteine	3,5	6,2	177,1	4,9	140,0	4,1	117,1	4,2	120,0
Tryptophan	1,0	1,1	110,0	1,1	110,0	1,1	110,0	1,2	120,0
Total amount of indispensable amino acids	36	45,9		41,1		43,7		42,2	
Alanine		5,0		5,3		5,8		5,7	
Arginine		6,1		7,2		5,6		6,0	
Aspartic acid		7,8		9,9		9,5		9,3	
Histidine		3,2		3,7		4,1		3,6	
Glycine		4,6		4,2		4,3		5,0	
Glutamic acid		15,2		16,4		15,5		15,7	
Hydroxyproline		1,7		1,6		1,6		1,4	
Proline		4,9		4,2		3,7		4,4	
Serine		4,3		3,8		4,2		4,1	
Total amount of essential amino acids		52,8		56,3		54,3		55,2	

synthesized in small amounts in a human body, are the most significant ones (for instance tyrosine, which is formed from phenylalanine) and human needs in them are mainly satisfied by means of animal-based products (Tutel'jan et al., 2010). To assess the protein quality the amino acid composition of kangaroo and other slaughter animals muscular tissues was studied to assess the protein quality. The results of those studies showed (table 2) that kangaroo meat was characterized by very high content of essential amino acids, the sum of which exceeded their amount in beef by as much as 22%, in calf by as much as 3.7%, in reindeer by as much as 4.8% as well as in the FAO/WHO standard amino acid sample (Pellett and Young, 1980). Kangaroo meat proteins don't have limiting amino acids, differ from other animals meat by high content of isoleucine and sulfur-containing amino acids. The score of all essential amino acids in the kangaroo muscular tissue is more than 100% that shows its proteins full-value. The results of the investigations of the amino acid composition of meat raw material proteins show that kangaroo meat is characterized by high biological value.

Designation: A – quantity of indispensable amino acid, g/100 g of protein; S – score value, %

Kangaroo meat lipid composition also differs from other animals' fat. In spite of the fact that the principal lipid classes in meat raw material are triglycerides and phospholipids their content differs depending on the kind of animals. In relationship of these lipid classes kangaroo meat is more useful as the content of phospholipids in it amounts up to 12.8% and the content of triglycerides is not more than 83.0%. The content of triglycerides in the reindeer meat lipids is not less than 90.0%, the content of phospholipids is 6.8%; the content of triglycerides in beef and calf is in the range of 91.0-93.0%, the content of

Table 3. The contents of individual water-soluble vitamins and minerals in the muscle tissue kangaroo and farm animals

Components	The daily requirement, mg/day (Tutel'jan et al., 2010)	Content (mg/100 g) in			
		Kangaroo Meat	Venison	Beef	Veal
Riboflavin	2,0-2,5	0,79±0,05	0,65±0,04	0,07±0,01	0,23±0,02
Thiamin	1,5-2,0	0,42±0,06	0,28±0,03	0,18±0,02	0,14±0,02
Potassium	2500,0-5000,0	417,0±16,8	331,0±8,0	217,0±6,3	198,0±6,0
Phosphorus	1000,0-1500,0	236,0±13,0	183,0±9,0	180,0±10,1	206,0±9,8
Iron	15,0	3,2±0,3	2,7±0,3	2,0±0,2	2,2±0,2
Zinc	10,0-15,5	3,5±0,4	2,6±0,2	2,8±0,4	2,9±0,3

Table 4 . Chemical composition and energy content of cooked sausages and canned beef and kangaroo meat

Components	The content			
	in the sausage from		of canned from	
	Beef	Kangaroo meat	Beef	Kangaroo meat
Water, %	67,4±1,6	74,8±1,8	58,9±1,4	67,5±1,7
Protein, %	18,1±0,9	19,9±1,1	18,3±0,8	20,3±1,0
Fat, %	13,3±0,7	4,0±0,5	21,6±1,4	10,9±0,7
Minerals, %	1,2±0,08	1,3±0,1	1,2±0,06	1,3±0,09
Riboflavin, mg/100 g	0,05	0,59	0,06	0,60
Thiamin, mg/100 g	0,13	0,31	0,15	0,32
Potassium, mg/100 g	162,7	312,4	188,7	362,0
Phosphorus, mg/100 g	135,0	175,0	156,6	203,0
Iron, mg/100 g	1,5	2,4	1,7	2,7
Zinc, mg/100 g	2,1	2,6	2,4	3,0
Energy value, kcal	192,1±11,0	115,6±9,0	267,6±15,8	179,3±10,4

phospholipids is 5.6-6.3%.

The analysis of the fatty acid composition showed (Fig.2) that the total content of unsaturated fatty acids in kangaroo meat was considerably higher than that in other animals. It is also an obvious advantage of kangaroo meat as they are nutrilites and fulfill many functions in a human body (Levachev, 1980). Polyunsaturated fatty acids should be fed to a human body with food as they cannot be synthesized in it. Besides, the ratio of different groups of fatty acids in kangaroo muscular tissue lipids is the closest to the recommended physiologically rational value (30:60:10) in comparison to that of other kinds of meat (Tutel'jan et al., 2010).

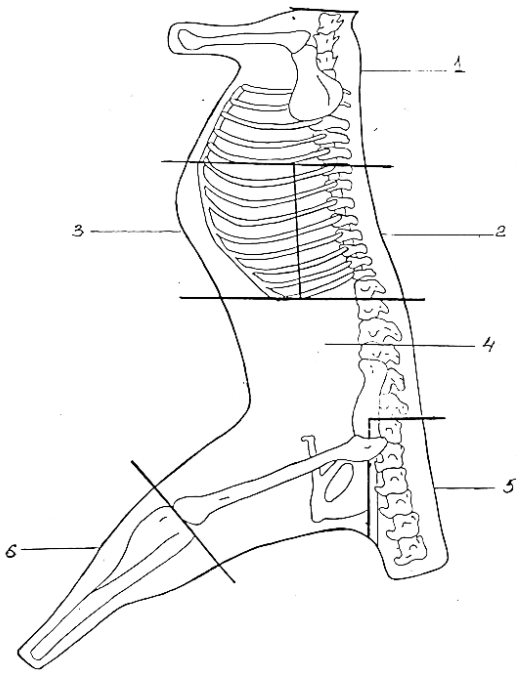

Fig. 1. Scheme butchering a kangaroo on a part: 1, 2, 3 – lobby: 1 - humeroscapular, 2- dorsal, 3 – sternal, 4, 5, 6 - coxal with the thick part of the tail and shank: 4 – coxal, 5 - thickest part of the tail, 6 - shank

Meat raw material bio-testing by express method (Shul'gin et al., 2006) showed that proteins digestion and relative biological value of kangaroo meat was not lower than those in other animals muscular tissues (Fig.3). Good digestion of kangaroo meat proteins, in our opinion, is due to their balanced amino acid composition and high content of the most digestible water soluble protein fraction as well as to the low content of saturated fatty acids.

The results of the investigation of the meat raw material vitamin and mineral composition showed (table 3) that kangaroo meat far outnumbered the traditional kinds of meat in the content of some vitamins and mineral substances and could be their sources. It was found that 100g of kangaroo meat could satisfy daily demand of a human body in riboflavin by 30-40%, in thiamine by 20-30%, in potassium by 16%, in phosphorus by 16-23 %, in iron by 23-35% and in zinc by 35-70%.

High content of iron in the kangaroo meat muscular tissue imparts more intensive dark-red colour to it in comparison to other animals meat and effects on the content of myoglobin and

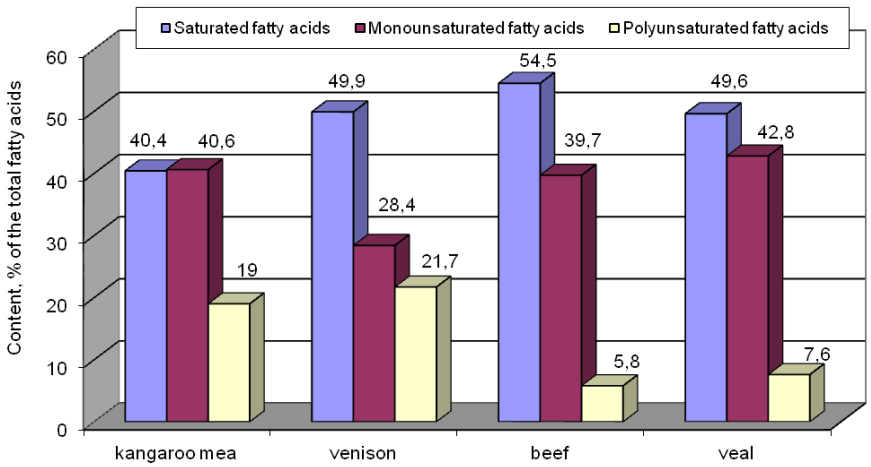

Fig. 2. The content of fatty acids in the lipids in muscle tissue of animals

cytochrome C (Antipova and Zherebcov, 1992). According to N.V.Potehina and her co-authors' data (Potehina et al., 2003), the amount of hemoglobin and cytochrome C is almost by as much as 2 times higher in kangaroo tissues than in beef tissues. High content of iron containing proteins in kangaroo muscular tissue will allow to maintaining the natural colour of meat products without adding sodium nitrite or colouring food additives.

All the above mentioned creates the possibility of using kangaroo meat for producing proper meat products for the diets of both the key population and for certain categories of population. Animal meat with low fat content, complete amino acid composition of proteins, rich in vitamins and mineral substances is known to be widely thought as dietetic food raw material (Tutel'jan et al., 2010). The stated results of the investigation show that kangaroo meat can be recommended for producing dietetic products.

Test samples of kangaroo meat-based cooked sausages and stewed meat type canned products were prepared. Cooked sausage in the sort of "Beef sausage" was produced in accordance with the technological instruction to the GOST R 52196-2011 "Cooked sausage products. Technical Conditions" The formulation composition of the sausage control samples included, (mass %): beef - 75.0, beef marrow - 15.0, eggs - 5,0, salt - 2.3, sugar - 0.1, ground black pepper - 0.1, ground common nutmeg - 0.05, sodium nitrite - 0.0056, water - 2.44. Beef fraction was completely replaced by kangaroo meat in the test samples. The technological process included the traditional stages of sausage production: defrosting, carving, dissection, trimming; preparing minced meat, additional materials and casing; minced meat mixture making, filling it into the casing, sausage links setting at the temperature in the range of 0-4 °C; heating, cooling, prepacking and packing. Prepared kangaroo meat-based sausage products didn't differ from the traditional ones in their appearance and were characterized by pleasant meat flavor and taste which are peculiar to this kind of products. Foreign flavors or smell specific for wild animals meat were not found. Kangaroo meat-based sausages were of moister consistency and of intense color but the beef-based sausages were of greyish tint.

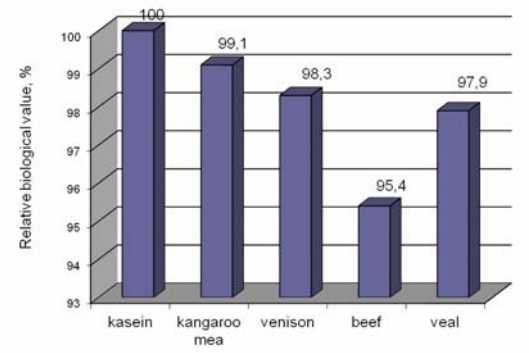

Fig. 3. The relative biological value (with respect to casein) of the kangaroo meat and farm animals

Canned products were produced in accordance with the Technological instruction on producing canned meat products "Stewed Beef", approved by the All Russia Scientific and Research Institute named after V.M. Gorbatov on February 20, 2001. The composition of the canned products control samples included the following components (mass. %): beef – 87.0, beef fat – 10.3, crushed bulb onion - 1.3, salt – 1.28, ground black pepper - 0.05, bay leaf - 0.02. Beef fraction was replaced by kangaroo meat in the canned products test samples formulations.

After defrosting, carving, dissection and trimming, the meat was proportioned and crushed into pieces of 10-15g. Prepared additional components were added to the mixture and stirred thoroughly, then filled into metal tins #6, net weight was 245g. The filled tins were closed and sterilized by steam at the temperature of 120 °C, proper sterilization lasted 50 minutes. The cans were cooled by water with counter-pressure 0.2 megapascals. Sterilization effect was 11.2 conditional minutes and it provided the industrial sterility. The ready-made control and test samples of the canned products were slightly different in their organoleptic properties.

They were characterized by pleasant meat taste and flavor, and there were no foreign flavor and odor.

Comparative characteristics of chemical composition and energy value of kangaroo meat-based cooked sausage and canned products samples are shown in table 4.

The amount of proteins in the control products samples containing kangaroo meat is by as much as 1.8-2.0 % larger than that in the test samples. The fat content in the sausage test

samples was by as much as 9.3 % and in the product cans by as much as 10.7 % lower than that in the control samples. As we can see the replacing of beef fraction of the first grade with kangaroo meat in sausages and canned products allows just increase the content of complete proteins and considerably decrease the content of animal fat and energy value. Low calorie meat products containing the least amount of fat and high biological value, containing vital nutrients are known to be widely thought as the healthy food including dietetic and therapeutic ones (Titov et.al.,1994; Tetuel'jan et.al.).

So, kangaroo meat-based low calorie meat products are useful for the population of different categories, especially for senior people, as they exclude extensive intake of saturated lipids and energy into their bodies.

Kangaroo meat-based sausage and canned products are more valuable in the content of some vitamins and mineral elements than beef-based products. The content of riboflavins in the product test samples is by as much as 10 times more and of thiamine is by as much as 2 times more than in the control ones. The content of riboflavins in 100g of kangaroo meat-based products allows provide daily requirements of a human body in it by 25.0 %, in thiamine by 20.0 %, in iron not less than by 16.0 %, and in zinc than by 17.0- 30.0 %.

Since kangaroo meat-based sausage and canned products are the sources of such functional ingredients as phospholipids, vitamins and iron, they can be classified as functional meat products.

Summary

The investigations conducted showed that kangaroo meat was highly competitive with the meat raw material of agricultural animals in its food and biological value.

It is safe and can be used as the main raw material for the large-scale production of new kinds of sausages and canned products. The balanced amino acid composition of proteins, low content of fat and saturated fatty acids, and availability of phospholipids defines kangaroo meat as a perspective source for obtaining low calorie dietetic meat products.

High content of some vitamins and mineral substances in the kangaroo meat-based products defines their functional importance.

Kangaroo meat application in the food industry will contribute to meat products assortment expansion and will allow obtaining healthy food products for the population of different categories.

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