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CALCULATION OF CARBON EMISSION RESULTING FROM POULTRY PRODUCTION UNDER THE CONDITIONS OF THE CENTRAL REGION IN EUROPEAN RUSSIA

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This paper is dedicated to the development and testing of the integral methods of calculation for greenhouse gas emissions estimation at key stages of the production and consumption of poultry meat under the conditions of the Central Region of European Russia. Five phases of the life cycle analysis are discussed from the feed production up to final consumption and waste disposal. Algorithms and examples of the specific greenhouse gas emissions calculation at all stages of the life cycle of poultry products under the conditions of Central Russia are shown in the text and as a source of the information industry statistics and monitoring obsen'ations in the frame of the LAMP project of RF Government were used. Particular attention is drawn to the comparative analysis of greenhouse gas emissions resulting from the most common technologies of production and consumption of meat products both in Russia and abroad. There are discussed the latest development trends and potentials for more environmental-friendly poultry production in Russia with purpose of the main greenhouse gases ($C0_2$, CH_4 and N_20) emission reduction to prevent adverse global changes in atmospheric composition, climate characteristics and biota. The most problematic environmental situations include the problems of disposing of manure and other organic waste at all stages of production and consumption (5 to 20% of unused waste). Total emissions of greenhouse gases are ranging from 10 to 12.4 kg of $C0_2$ per 1 kg of produced and consumed meat products, which is 15-20% higher than in Western European counterparts. It is important to note that this reflects not only the environmental shortcomings of the organization of production, but there is significant potential for increase in its cost-effectiveness by improving the work with organic waste and byproducts.

Key words: Global changes, greenhouse gases, emissions, meat, poultry, feed, agriculture, processing, consumption, carbon footprint.

One of the major problems of modem society is the ever increasing human population and its anthropogenic pressure on environment. Anthropogenic emissions of greenhouse gases (GHG) are representing the most important and the most acute problem of the modem ecology [11, 12]. Humans need a lot of high quality proteins, which are mostly obtained from meat, which has as a consequence the main challenge for the modem agriculture: the provision of sufficient quantities of safe food to the constantly growing human population with the efficient use of the limited quantity of natural resources. Currently, the agriculture sector allocates about 16% of global greenhouse gas emissions, which is comparable to greenhouse gas emissions from other sectors of the economy (energy, industry, transport), and livestock sector is producing more GHG than other forms of food production, mainly methane and nitrogen oxide [11, 18].

With ever decreasing area for fodder production, the intensive livestock technologies are becoming more and more interesting because they are using resources with the highest efficiency, which has as a result the cheapest product per unit. The poultry production is the most intensive field of the animal husbandry with the lowest price per unit of product. For this reason poultry is the most common source of meat in the developing countries (Fig. 1). As the developing countries have the biggest human population the population of birds (chicken) is the biggest as well, and because of that the environmental pressure (which is small when we are observing only one animal) is cumulative and represents serious problem.

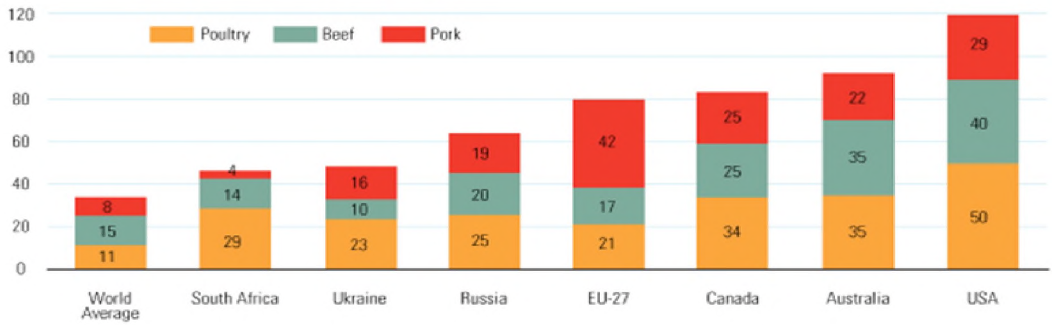

Fig. 1. Global meat consumption per capita in 2009 [7]

Another important aspect is that in the future population will grow, especially in the developing countries, which in combination with improved economic situation, will result in the increased demand and consequentially increased production and anthropogenic pressure on the environment (Fig. 2). The Russian Federation will increase total consumption

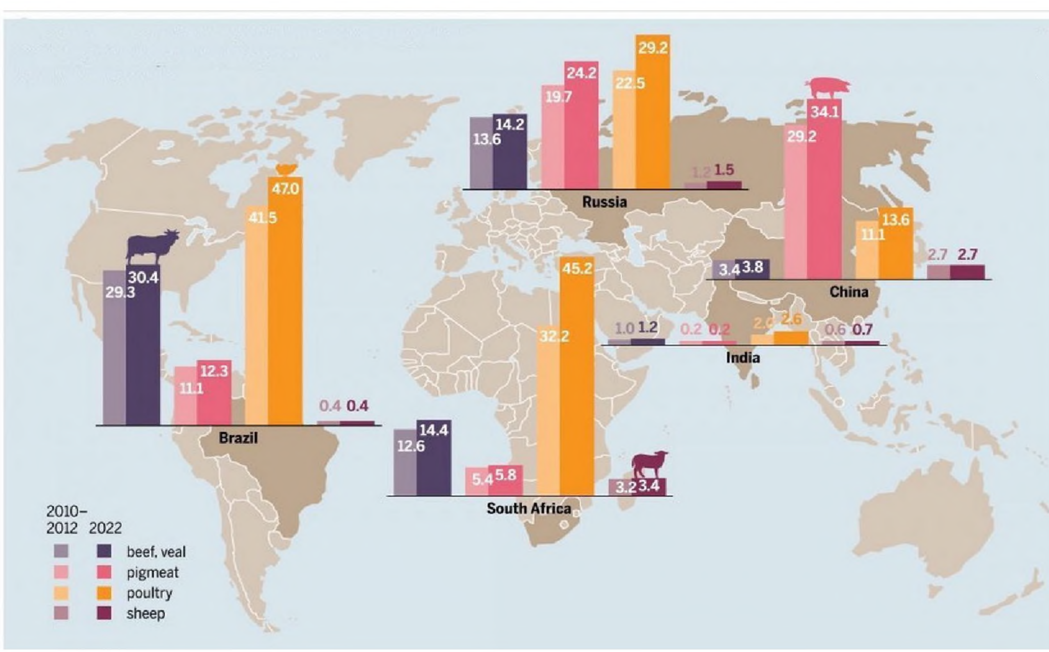

Fig. 2. Estimation of the meat consumption per capita in 2012 and 2022 [7]

of all kinds of meat by 11.8 kg per capita, with the poultry meat share of 56.8% in this increase. Because of its livestock development program and increase in the production of meat Russia should have a clear idea about the allocation of greenhouse gas emissions at each phase of the animal production.

The aim of this work is to develop an analytic algorithm of the main greenhouse gases emission in all stages of animal (chicken) products life cycle analysis (LCA) according to regional typological features of agricultural production in agro-ecosystems (Fig. 3). The methodology of CF LCA calculation includes the life cycle of a product from the production of the raw materials up to the disposal ("from cradle to grave").

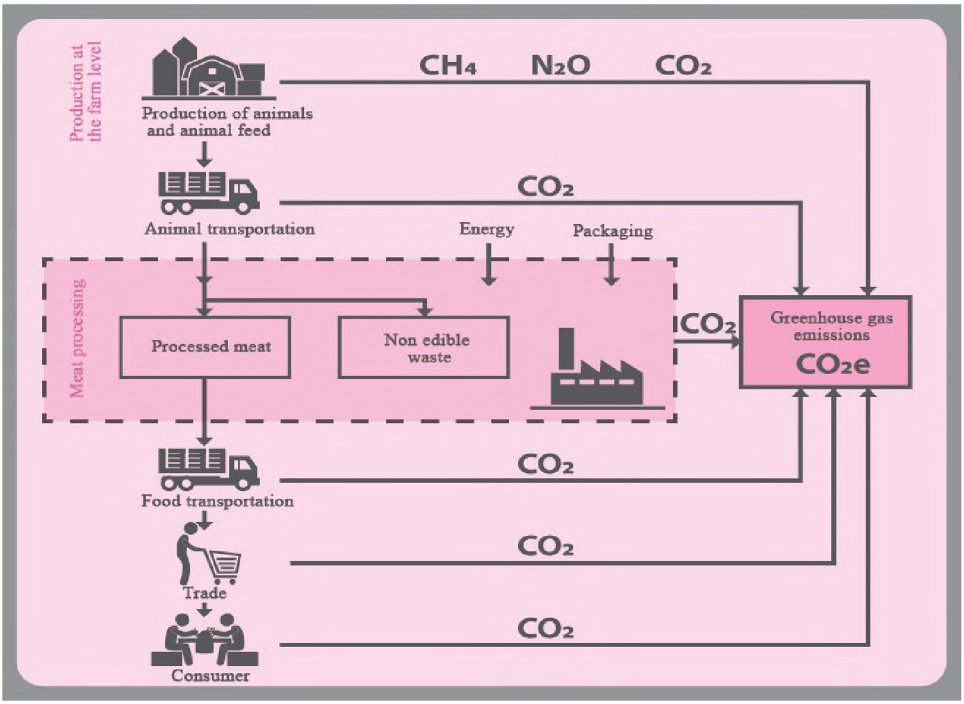

Fig.3. GHG emissions and their composition on the main phases of the LCA [20]

Goals and Methods

The goal of this work is to show the calculation procedure for estimations of the Carbon footprint (CF) of an agricultural product (chicken meat) under the conditions of the Central region of Russia.

Different GHGs are exhibiting different greenhouse effects so their impact is calculated through the global warming potential (GWP) which represents effect comparison of particular greenhouse gas with that of $C0_2$ in a 100-year period. GWP of carbon dioxide is 1, the GWP of methane is 23 and the GWP of nitrogen oxide is 296 (i.e., 1 kg of methane has the same effect as 23 kg of carbon dioxide) [6]. Unit of measurement of GWP is kg equivalent of $C0_2$ (kg $C0_2$ e). The Carbon Footprint (CF) shows the amount of GHGs released during production of unit of some good or service expressed in terms of kg $C0_2$ e. As a functional unit we will use 1 kg of meat with bone (carcass weight).

The Carbon Footprint calculation in the livestock and meat production LCA can be divided into 5 principal phases (Fig. 4):

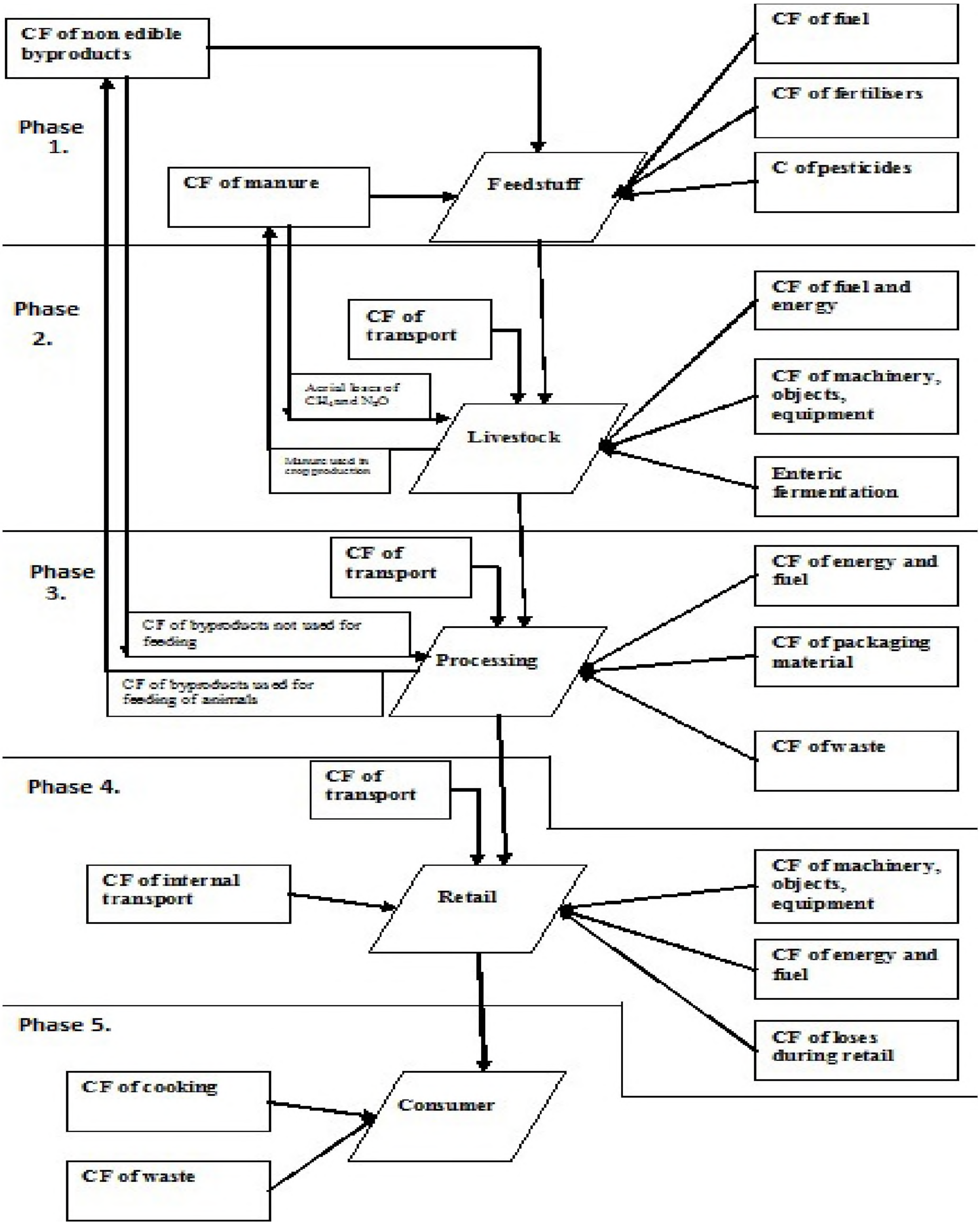

Fig. 4. GHF emissions algorithm analysis in the processes of poultry production LCA under the conditions of the Central region of Russia

Phase 1: GHGs emission analysis at the stages of feed and crop production (for the poultry production) under the conditions of representative agrolandscapes.

Phase 2: GHGs emission analysis at the stages of livestock (chicken) production under the conditions of representative farms.

Phase 3: GHGs emission analysis at the stages of meat processing under the conditions of representative plants.

Phase 4: GHGs emission analysis at the stages of chicken meat retail under the conditions of representative supermarkets.

Phase 5: GHGs emission analysis at the stages of consumption.

There are two types of poultry production in Russia: the first type is with feeding period of 42 days and weight of 1900 g, and the second one is with feeding period of 56 days and end weight of 3300 g. The first method is more intensive and feed- and cost-efficient than the second one due to different feed conversion (amount of feed needed for 1 kg of growth) in different age of the birds as well as to more efficient and balanced feeding in the first system (Table 1).

Table 1

The difference in feeding systems between two types of poultry production [15]

Type of Techno-logy	Bodyweight at the end of growth (kg)	Feed conversion (kg feed/kg growth)	Age of the Animals (days)					
			0–10	11–20	21–30	31–42	42–49	50–56
42 Days	1.9	1.76	Starter 1 22% of proteins	Starter2 20% of proteins	Grower 19% proteins	Finisher 17% of proteins	–	–
56 Days	3.3	2.1	Starter 1 22% of proteins			Grower 19% of proteins		Finisher 17% of proteins

The calculation takes into account each stage and includes transportation within the production chain from the first step up to the defined border of the system (the end of the chain or the end of the chain segment). Methodology described in this article is based on IAGRICO, [3].

Practical example of the CF calculation

The practical example has been developed on the basis of the poultry production in the Central Chernozem region of the Russian Federation (based on data obtained on the farms of the educational facility «Mumovskoye» in Saratov region, complex data obtained through LAMP field experiments in Kursk region as well as on information received through LISSOZ [21] program application).

There is also a fixed CF value for the buildings and the equipment, which is distributed along their whole lifetime, so their CF per unit of product is so small that can be ignored as a significant factor in total CF of the product.

For this phase in the food chain the most important factor is the emission of $C0_2$ because of fuel consumption (both in tillage and animals feeding) and N_20 emissions resulting from fertilisers production and application as well as transformation of the ammonia from manure to nitrates followed by denitrification processes.

Phase 1: Feed and Crop Production.

At the start of the GHGs from the feed production's calculation we need to calculate the needed amount of feed [14] for the animals' growth to the slaughter weight (Fig. 5). According to the empirical data obtained in Kursk and Saratov regions the medium length of the feeding period for the chicken is 42 days, at this age the body mass of the animal is near of 1800-2100 g (we will take 1900 g as a mean weight).

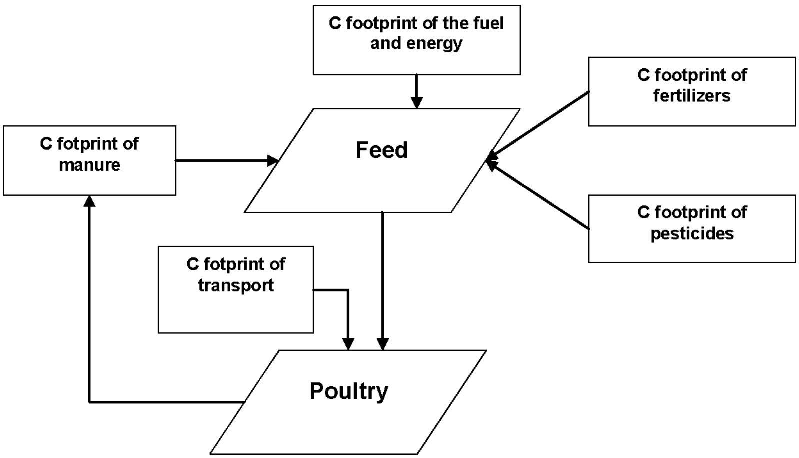

Fig. 5. Diagram of the greenhouse gas emissions in the Feed and Crop Production Phase

During the lifetime animals eat 1.50 kg of maize, 0.7 kg of wheat, 0.4 kg of barley and 0.8 kg of soybean, GHGe for the given amount of feed is calculated from the emissions of the production inputs per hectare under given culture. In order to determine the GHG emission from fertilizers we need to know how much GHGs are released through production and application of fertilizer. During the process of fertilizers production 6.8 kg $C0_2$ e kg^{-1} of N in the fertilizer is released into the atmosphere [4], and 1% of the N introduced by fertilizers is released from the soil in the form of N_20. The average amount of N applied per hectare in the Chernozem region and calculated values of GHG emissions are shown in table 2.

Table 2

Amount of N applied per hectare and calculated values of GHG emissions

Crops	Applied N per hectare (kg)	GHG emissions per hectare (kg CO_2 e)	GHG emissions per kg of grain (kg CO_2 e)
Maize	130	1269	0.32
Wheat	120	1756	0.29
Barley	220	2147	0.36
Soybean	228	2225	0.74

For the calculation of the $C0_2$ emission from fuel consumption we need to multiply the quantity of used fuel by the factor of $C0_2$ release. As far as the main fuel in the agricultural production is diesel fuel we need to multiply litres of diesel fuel by factor 2.64 (kilograms of released $C0_2$ per litre of used diesel). The needed quantities of diesel fuel for forage crops growing are shown in table 3. The calculated crop yields are the following: wheat — 6 t/ha, maize — 5 t/ha, barley — 6 t/ha, soybeans — 3 t/ha [20]. From the data provided we can calculate the CF of every kind of feed per kilogram (Table 4).

Table 3

Amount of fuel used per hectare and calculated values of GHG emissions

Crops	Used fuel per hectare (litres)	GHG emissions per hectare (kg $C0_2$ e)	GHG emissions per kg of grain (kg $C0_2$ e)
Maize	120	316.2	0.06
Wheat	73.52	194.1	0.03
Barley	69.05	182.3	0.03
Soybean	65	171.6	0.06

After multiplication of needed amount of feed (kg) by CF of the feed (kg $C0_2$ e) and supposing that the losses in feed amount to approximately 5% we obtain as a result the amount of released GHG in the process of feed production per animal:

$$(0.38x1.5 + 0.32x0.7 + 0.39x0.4 + 0.8x0.8) + 5\%$$

It is equal to the total CF of 1.65 kg $C0_2$ e from the feed ingested by animal.

Table 4

Carbon Footprint of the specific feeds

Feeds	Carbon Footprint of Feed (kg $C0_2$ e)
Maize	0.38
Wheat	0.32
Barley	0.39
Soybean	0.8

Phase 2: Poultry Production.

Concerning poultry as a source of the GHG emission the main sources are energy consumption for feeding and accommodation of the animals and manure management (Fig. 6). Fuel consumption for feeding, manure handling and internal farm transport for the poultry is 0.005 litres of diesel per bird, which is equal to 0.0132 kg $C0_2$ e.

Total amount of electricity consumption per bird is 0.25 kWh. According to the data for $C0_2$ release per kWh in the Russian Federation (provided by [5]) every kWh produced in Russia emits 0.699 kg $C0_2$ e. Multiplying required quantity of electric energy by consumption we get the result of 0.174 kg $C0_2$ e released due to electricity consumption in animal's lifetime. The amount of gas needed for heating reaches 1.55 kWh and of natural gas which is usually used for heating has CF of 1 kWh equal to 0.19 kg $C0_2$ e, so heating is adding 0.29 kg $C0_2$ e.

GHG emissions as a result of manure handling are almost exclusively important when N_20 is considered. The amount of nitrogen which is released into atmosphere depends on manure handling and storage practices. In Russia the main way of manure storage is in form of piles (not protected by any mean with free gas emission from manure). In

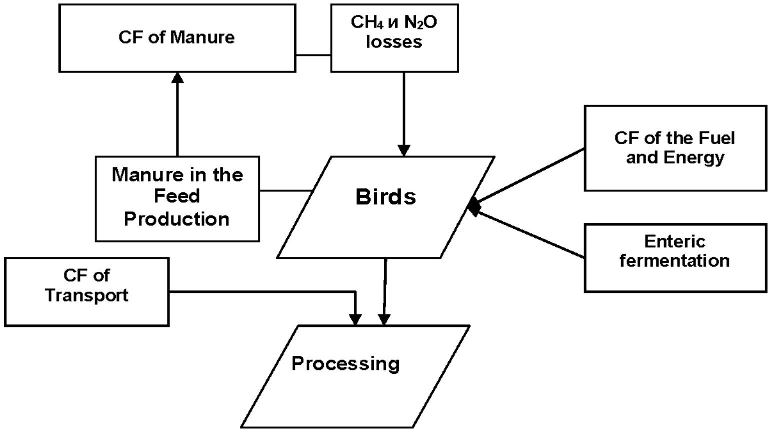

Fig. 6. Diagram of the greenhouse gas emissions at the Poultry Production Phase

those circumstances 40% of total N is lost and around 3% of this amount is transformed into N_20, which is equal to 0.004 kg of N or 0.006 kg of N_20 with GWP of 1.78 kg $C0_2$ e. From the given data we can calculate total amount of emitted GHGs in rearing of 1 bird with weight of 1.9 kg:

$$1.65 + 0.0132 + 0.174 + 0.29 + 1.78$$

It is equal to 3.91 kg $C0_2$ e.

Phase 3: Processing.

The processing represents complex of the procedures, treatments and processes which are converting animal tissue to the meat (Fig. 7).

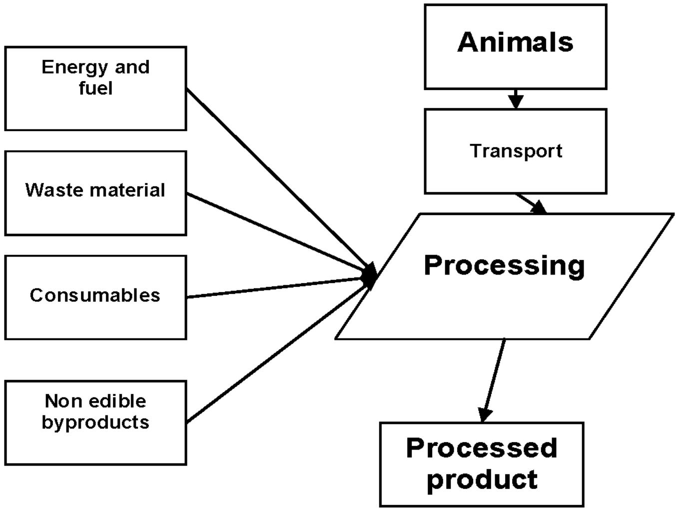

Fig. 7. Diagram of the greenhouse gas emissions in the Phase of Processing

3.1. CF of Animals' Transport.

Vehicles used in animal transport are mostly diesel fuelled. According to European standards in container transport of chickens the floor space required for one bird varies within 180 — 200 cm^2. Standard dimensions of trailers for animal transport are the following: length 13.60 meters, width 2.60 meters and height 2.90 meters. Consumption of diesel fuel per 100 kilometres fluctuates from 25 to 30 litres, which releases from 66 to 79.2 kg of $C0_2$ e per 100 kilometres. To sum up, transport contributes to the carbon footprint of meat for poultry from 0.025 kg $C0_2$ e per kg of meat per 100 km (single-storey transport) to 0.0065 kg $C0_2$ e per kg of meat per 100 km (four-storey transport), or per a bird — from 0.049 to 0.01235 kg $C0_2$ e per kg of meat per 100 km. Normally birds are transported in the four-storey containers for costs reasons so transport is adding to total CF of meat production 0.012 kg $C0_2$ e per kg of meat per 100 km.

3.2. CF of the Processing Energy.

According to literature information [19], the amount of used energy during processing is directly related to the degree of production intensity. Slaughterhouses and meat processing plants with higher capacity and with more intensive processing, with modem equipment and higher energy efficiency will result in less energy consumption per unit of product.

According to obtained data in Russia for meat processing it is necessary to provide 3.8-4.4 cubic meters of water with temperature of 65 degrees per ton of processed meat, which depends not only on the animal species, but also on the technological level of the equipment and the intensity of treatment, a more intensive technology. Since for water heating natural gas is used then the carbon footprint amounts to 0.19 kg $C0_2$ e per 1 kWh. To heat water from 10 to 65 degrees we need 0.0011 kWh per litre per °C, thus, we can calculate carbon footprint of water heating which is 60.5 kWh/m^3.

For heating water for 1 ton of meat production and processing it is released from 43.681 kg of $C0_2$ to 50.578 kg of $C0_2$. Usage of water vapour needed per 1 ton of meat varies from 0.4 to 0.5 m^3 and the consumption of energy per production of kg of vapour fluctuates between 0.22 and 0.275 kWh (0.0418-0.0525 kg $C0_2$ e).

Consumption of energy for production of water vapour needed for one ton of meat (24.5 to 36.7 kWh) releases 16.04 to 25.65 kg $C0_2$ e per ton of meat which gives 0.069 kg $C0_2$ e per 1 kg of poultry meat.

3.3. C footprint of non-edible by-products.

a. The ratio of edible and inedible parts of carcasses in broilers are 75-80% vs. 20-25%, which gives us a value of 1.44 kg of edible parts vs. 0.365 kg of non-edible parts. Animal waste which cannot be further processed in the meat and bone meal is around 5% of the total weight of an animal (0.095 kg) [19]. So it can be concluded that CF for kg of edible parts of one bird is:

$$((3.91 + 0.012)x(1.44 + 0.095)) + 0.069 = 6.094 \text{ kg } C0_2 \text{ e}$$

b. Evaluation of non-edible by-products Carbon footprint: In Russia non-edible by-products is used as a protein feed for animals and because of that their carbon footprint can be determined by carbon footprint of protein feed component of plant origin which they replace. As non-edible by products are processed into meat and bone meal with protein content of 40 to 45% we can replace soybean meal with it in the ratio of 1:1 and to equate the Carbon footprints of soybean meal and meat and bone meal [19]. In this case:

$$0.2x0.8 = 0.16 \text{kg } C0_2 \text{ e per kilogram of by-product}$$

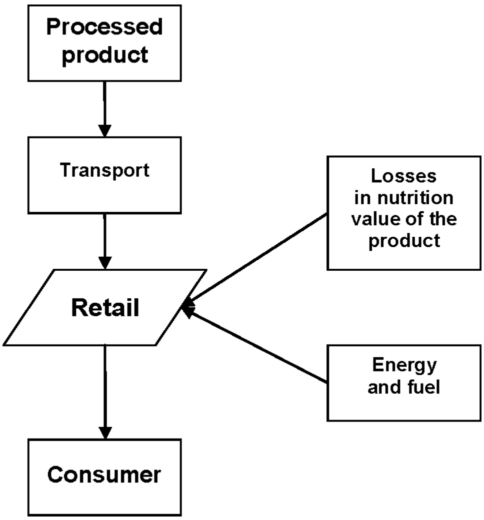

Fig. 8. Diagram of the greenhouse gas emissions in the Phase of Retail

Phase 4: Retail.

GHGs emission analysis at the stages of chicken meat retail has been done for the conditions of representative supermarkets in the Central Region of Russia (Fig. 8).

4.1. CF of the Meat Transport.

The processed meat is usually transported in trucks with maximum load 10 to 25 tons. When calculating fuel consumption we need to be aware that medium load of meat is 50% of maximum load of the vehicle. Also consumption of fuel is increasing due to low temperature conditions: deep frozen meat increases fuel consumption by 22%, and chilled meat by 11% comparing with fuel consumption of equally loaded vehicle without cooling system [2].

A litre of diesel fuel produces 2640 g $C0_2$, and vehicle consumption of diesel fuel at a load of 20 tons is on average 35 litres per 100 km. The medium load factor of the truck for meat is 50% (10 tons — 10.000 kg), and the consumption of fuel in case of frozen meat is 30.5 litres per 100 km and in case of chilled meat — 27.75 litres per 100 km, which converted into $C0_2$ equivalent gives 80.52 kg for frozen (0.08 kg $C0_2$ e per kg of meat) and 73.26 kg of $C0_2$ per 100 kilometres for chilled meat (0.07 kg $C0_2$ e per kg of meat).

4.2. CF of the Package.

The main purpose of packaging is to protect the meat and meat products from unwanted impact on their quality, including microbiological and physico-chemical changes. In the Russian supermarkets, polystyrene plates are used for meat packaging. Carbon footprint of polystyrene is 3.45 kg $C0_2$ e [17] and the average weight of the plates for packing of 1 kg of meat is 42.3 g (39-43 g).

For wrapping the plates monolayer and multilayer films are used usually from the following materials: polypropylene, polyethylene, polyvinyl chloride and polyester. Carbon footprint of polypropylene (PP) and polyvinyl chloride (PVC) is 3.45 kg $C0_2$ e, polyethylene (PE) 3.38 kg $C0_2$ e, polyester (PET) 4.53 kg $C0_2$ e [1].

The average weight of films for packaging of the meat is 6.2 g (5.8- 6.5 g) per 1 kg of meat. From the abovementioned parameters, we can calculate the C footprint: 0.146 kg $C0_2$ e for polystyrene plates and 0.02 kg $C0_2$ e for PP, PVC, PE and PET films.

4.3. CF of energy used in the retail sector.

Energy consumption for refrigeration in retail is quite high due to open refrigerators and it is equal to 0.056 kWh kg^{-1} of meat per day which gives us CF of 0.039 kg $C0_2$ e day^{-1} per kilogram of meat [2] and the total CF of energy needed for cooling and storage is 0.078 kg $C0_2$ e per kilogram of meat.

Around 20% of total meat in the retail is lost due to either damaged packaging, expired usage date, losses of nutritive values etc., so end calculation of CF at the end of retail phase will be as follows:

For frozen meat: (6.094 + 0.08 + 0.146 + 0.02 + 0.078) + 20% = 7.7 kg CO, e

For cooled meat (6.094 + 0.073 + 0.146 + 0.02 + 0.078) + 20% = 7.69 kg $C0_2$ e

Phase 5: Consumption.

After purchasing meat is not prepared immediately but it is stored in the refrigerator usually for one day (Fig. 9).

Refrigerator consumes annually 0.78 kWh per liter of its volume, and if we assume that the average volume of the refrigerator is 145 liters then the annual electricity consumption makes up 113 kWh, i.e. 0.31 kWh per day (0.22 kg $C0_2$ e per day) [2]. Preparation of 1 kg of meat requires 4 kWh (2.8 kg e $C0_2$ from electricity or 0.76 kg of $C0_2$ from natural gas).

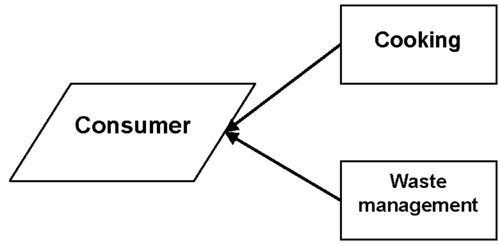

Fig. 9. Diagram ofthe greenhouse gas emissions at the Phase of Consumption

From this data we can calculate CF of the prepared meat:

CF of the cooled meat = 7.69 + 0.22 + 2.8 = 10.71 kg of $C0_2$

CF of the cooled meat = 7.69 + 0.22 + 0.76 = 8.67 kg of $C0_2$

CF of the frozen meat = 7.7 + 0.22 + 2.8 = 10.72 kg of $C0_2$

CF of the frozen meat =7.7 + 0.22 + 0.76 = 8.68 kg of $C0_2$

Content of the bones in the meat (1 kg of meat with bone in carcass weight) of broilers is 15%, swhich together with the packaging represents waste. The CF of the waste and packaging are calculated at the end of the product's life:

CF of the cooled meat waste = (7.69 + 0.22 + 2.8)xl5% = 1.61 kg e $C0_2$
(in the case of electricity)

CF of the cooled meat waste = (7.69 + 0.22 + 0.76)xl5% = 1.3 kg e $C0_2$
(in the case of gas)

CF of the frozen meat waste = (7.7 + 0.22 + 2.8)x 15% = 1.608 kg e $C0_2$
(in the case of electricity)

CF of the frozen meat waste = (7.7 + 0.22 + 0.76)x 15% = 1.3 kg e $C0_2$
(in the case of gas)

Conclusion

According to the performed analysis of the GHG emissions basic sources in the life cycle of the poultry meat we have concluded that the most efficient way of greenhouse gases emission evaluation and assessment is integral algorithm of GHG emission calculation which is divided into 5 phases of the LCA: (1) feed and crop production, (2) livestock (chicken) production, (3) meat processing, (4) retail, (5) consumption. Every phase is characterized by specific emission factors. Regulation of those emission factors is providing us with means for reduction of this specific anthropogenic impact on the environment.

The first phase is connected with analysis of the applied fodder technologies under the concrete soil, climate and agroecological conditions. Those conditions are defined by maximum essential spatial variability and temporal changes, which determine priorities in their studying under the conditions of the Central regions of European part of Russia. We need to take into consideration the difference between traditional and modem ways of tillage and corresponding GHG emission.

The second phase is characterised with high level of applied zootechnologies unification with dominating contrast variants of high intensity poultry business (imported bird varieties and housing and feeding technology) with ever reducing segment of extensive technologies of poultry business under the conditions of CRER. Conducted analyses had shown intensive lowering of the CF with replacement of older technologies by modem ones, chiefly by decreasing growth time and improvement of the feed conversion (42 days vs. 56 days of growing, 1.76 kg of feed vs. 2.1 of feed per 1 kg of weight), which should be included in the efficiency assessment of the modernisation projects of poultry farms.

The main feature of CRER is low efficiency of the manure utilisation, which results in high emissions of the nitrogen oxide. This is the field where the implementation of the intensive technologies of manure handling, utilisation and management will significantly decrease GHG emission [13].

The third phase shows the highest level of unification between the Russian technologies and the ones used in Europe and USA, which is giving us an opportunity of application of European and US CF calculations in our analysis of the GHG emissions. The main differences between European and CRER are lower intensity of the non-edible products and waste rendering and utilisation, which has as a result higher energy consumption per unit and higher GHG emissions.

The fourth phase in Russia is specific in that way that there are characteristic market conditions, originating from the differences as well as distances between the big cities, small cities and villages. In Russia's poultry meat market we have great diversity of the market subjects (big supermarket systems, local general stores, specialised meat stores, farmer's markets etc.). Because of given heterogeneity of the market conditions the amount of losses in the processed meat is as high as 20%, which is resulting not only in the increase of GHG emission, but also in the accumulation of the organic waste.

The fifth phase under Russian conditions differs greatly from the most developed countries because of complete lack of the differentiation in the solid waste collection, which has as a consequence increased value of the CF of meat. To remedy this problem we need to implement practice of the separation and recycling of solid waste and composting of the organic solid waste. It is of greatest importance for Moscow region, where high density of population leads to great quantity of organic solid waste, utilisation of which can be of interest both for potential investors from financial point of view and for society from environmental side.

Our analysis has shown characteristic increase of the GHG emission per the unit of meat production in comparison with almost equal values in Russian and foreign poultry growth and processing.

The most important problems are in the fodder production, also utilisation of manure as well as waste from phase 4 and 5. The most typical characteristics for Russia are great distances, which require consequently greater energy consumption for transport, as well as transport — deriving CF, which must be taken into account when calculating the CF is performed, as well as ideas for reduction through better planning of the poultry farming, processing and retail systems, which is already showing trend of improvement.

Above-mentioned differences in the technologies are showing the need for the modem informational support of CF automatic calculation at all five phases of the LCA. The algorithms for this kind of calculation are in the developing stage at the RSAU, and final product is supposed to be in the form of the open source on-line calculator.

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РАСЧЕТ ЭМИССИИ УГЛЕРОДА В СИСТЕМЕ ПТИЦЕВОДСТВА В УСЛОВИЯХ ЦЕНТРАЛЬНОГО РЕГИОНА ЕВРОПЕЙСКОЙ ЧАСТИ РОССИИ

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Статья посвящена разработке и апробации интегрального способа расчета выбросов парниковых газов на ключевых стадиях производства и потребления мяса птицы в условиях Центрального региона европейской территории России. Рассматриваются пять стадий анализа жизненного цикла — от производства кормов до конечного потребления и утилизации отходов. Представлены алгоритмы и примеры расчета удельной эмиссии парниковых газов на всех этапах жизненного цикла продукции птицеводства с использованием отраслевых статистических материалов и мониторинговых наблюдений ЛАМП в рамках проекта Правительства РФ. Особое внимание обращается на сравнительный анализ эмиссии парниковых газов в результате применения наиболее распространенных в России и за рубежом технологий производства мясной продукции и ее потребления. Обсуждаются современные тренды развития и потенциал экологизации птицеводства в условиях России с сокращением эмиссии основных парниковых газов ($C0_2$, CH_4 и N_20) для предотвращения неблагоприятных глобальных изменений состава атмосферы, характеристик климата и биоты. К наиболее проблемным экологическим ситуациям относятся проблемы утилизации помета и других органических отходов на всех стадиях производства и потребления (от 5 до 20 % неиспользуемых отходов). Суммарный объем выбросов парниковых газов варьирует от 10 до 12,4 кг $C0_2$на 1 кг произведенной и потребленной мясной продукции, что на 15-20% выше средних показателей для западноевропейских аналогов. Важно отметить, что это свидетельствует не только об экологических недостатках организации производства, но и о наличии значительного потенциала повышения его экономической эффективности при улучшении работы с органическими отходами и остатками.

Ключевые слова: глобальные изменения, парниковые газы, эмиссия, мясо, птицы, корм, сельское хозяйство, переработка, потребление, С-футпринт.

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