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SCIENTIFIC ACHIEVEMENTS IN ENVIROMENTAL AND LIFE SCIENCE

PREDICTING METHOD OF THE ENERGY BALANCE FOR RUMINANTS

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KEYWORDS

gross energy, digestible, exchange, balance, feed and ration evaluation, ruminant animals.

SUMMARY

The article presents various approaches and methods of the energy balance predictionfor ruminants in particular:

1. Investigation of gas and energy exchanges in experiments.
2. Preparation of the energy balance by the calculation method.
3. Using the balance method for predicting the energy value of feed and ration for cattle.
4. Biological and methodological approaches to heat balance.

These techniques provide an opportunity to predict and analyze the energy balance for ruminants and according its approaches carry out the energy evaluation of feed and rations in the content of gross and clean energy in contrast of existing ones.

INTRODUCTION

The world experience in livestock development shows that progress in raising productivity and reducing the cost of livestock products is determined about 35% by the achievements of genetics and breeding. The main part of the productivity increase is achieved through the rational feeding of animals. Foreign and domestic scientists state that the nutritional value of feed is 50-60% due to its energy content, about 20-30% by the presence of digestible nitrogenous substances and 20-30% is the content of other constituents. That is why it is very important to evaluate objectively the energy exchange in the animals' organism.

INVESTIGATION OF GAS AND ENERGY EXCHANGES IN EXPERIMENTS

Establishment of the mechanism of external factors influence on the animals'organism is very important for zootechnical science. The classic methods, by which over two centuries are trying to explain their influence,are the study of digestion and the balance of nutrients and individual organic and mineral elements. Unfortunately, in most cases the explanations are reduced to the statement of facts as following: digestibility increases, the balance is positive and is better absorbed that does not always make it possible to understand the mechanism of action of one or another factor of the metabolism and energy. In ruminants, a complex transformation of nutrients in the rumen is carried out by microorganisms with the destruction of some parts and the synthesis of other substances, which prevents the balance and determinesobjectively the digestibility of nutrients. For ruminants, the most accurate is the compilation of the energy balance as an integral indicator of all metabolic processes [1].

For many years, we have worked out a methodology for the study of gas-energy metabolism in animals using a mask method of 5-minute sessions for 1-2 hours until morning and in 3-4 hours after each feeding two adjacent days in succession, changing the animals order of the next day during the sessions to the opposite.

The reverse order of sessions of respiratory research allows to eliminate partially the influence of time factor. This is because the consumption of one animal lasts 7-8 minutes (including fixing and removing equipment, switching from one animal to another), and for 9-12 animals it is from 1 to 1.5 hours.

On the basis of respiratory research the ventilation of lungs and the number of air exhaled by animals are determined taking into account the conversion factor, which magnitude depends on temperature and barometric pressure (to barometric pressure of 760 mm Hg and temperature of 0°C); the amount of consumed oxygen is the difference in the amount of isolated oxygen and carbon dioxide, respiratory (respiratory); depth and frequency of breathing; utilization of oxygen, etc.

The total heat production is calculated by the amount of consumed oxygen and its caloric value depending on the value of the respiratory factor:

$$HP = O2\ (15.986 + 5.144\ RF), \text{ or} \quad (1)$$

$$HP = O2\ [15.986 + 5.144\ (CO2:\ O2)], \quad (2)$$

where: HP - heat production, kJ;

O2 - quantity of consumed oxygen by the animal for a certain period of time, l;

CO2 - amount of carbon dioxide isolated, л;

RF - respiratory factor - the ratio of CO2 to O2.

Nowadays, very rarely, the authors of scientific studies try to balance energy, as in most cases its scheme has a number of inaccuracies (Table 1). In addition to feed and feces, the rest of the indicators are calculated either through the amount of nitrogen, or as a percentage of the digestible energy. Thus, the energy of gases is determined by calculation, often depending on the amount of digestible energy and the coefficient of its digestion, which does not always correspond to reality. In addition, Kelner O. deduced the dependence: the more fiber in the animal's diet, the more energy is consumed with gases. Heat of fermentation in most experiments isnot calculated at all.

Tab. 1. TRADITIONAL ENERGY BALANCE IN THE CATTLE ORGANISM

Indicator	Method of determination
Gross Energy	Chemical composition or calorimetry
Fossil fuels	Chemical composition or calorimetry
Energy of digestible substances	Calculation
Urine Energy	Calculation
Gas Energy	Calculation
Heat of fermentation	No counting or calculation
Exchange Energy	Calculation
Products Energy	Calculation
Heat production	Calculation

Thus, digestible, exchange and pure energy is determined in balancing experiments with a significant proportion of probable errors and inaccuracies.

We offer a methodology for calculating the energy balance based on the calculation of gross energy of the diet and heat production, as these are two objective indicators, the initial and final result of the interaction of the feed, organism. Having determined the heat production in the experiment, so it can make up 80 to 100% of the exchange energy. The energy of feed and ration is calculated quite accurately by the regression equation:

$$GE = 23.95 \times RP + 39.77 \times RF + 20.05 \times CF + 17.46 \times CNSE \quad (3)$$

where: GE - gross energy;

RP - raw protein;

RF - raw fat;

CF- crude fiber;

CNSE - crude, non-saturated extractives.

To determine the energy value of feces, use the same equation multiplied by 1,054. More precisely, it could be determined by direct calorimetry.

The energy emitted from gases is determined by the equations:

$$EGc = 0.963 \times (SC + CNSE), \quad (4)$$

$$EGaa = 1.675 \times (SC + CNSE), \quad (5)$$

where: EGc- energy of gases in calves;

EGaais the energy of gases in adult animals.

The energy released by fermentation in the rumen:

$$FHC = 0.385 \times (SC + CNSE), \quad (6)$$

$$FHaa = 0.670 \times (SC + CNSE), \quad (7)$$

where: FHC - fermentation heat in calves;

FHaa - fermentation heat in adult animals.

The energy that is allocated with urine is determined by:

$$UE = 3.592 \times CP, \quad (8)$$

where: UE - urine energy

CP is a crude protein.

Knowing the amount of consumed gross and exchange energy, with great accuracy, you can determine the amount of digestible using the above formulas.

Thus, having determined in the respiratory research the value of heat production and calculating the energy value of the product, you can determine the amount of exchange energy by the equation:

$$EE = HP + NE\ pr \quad (9)$$

where: EE - exchange energy;

HP - heat production;

NE pr - the net energy of production.

Preparation of the energy balance by the calculation method.

The value of heat production can be determined by the calculation method by the equation:

$$HP = 41.37 + 0.1346 \times LW + 31.97 \times ADG – 5.853 \times CEE, \quad (10)$$

where: LW - live weight, kg;

ADG - average daily gain, kg;

CEE - the concentration of exchange energy in 1 kg of dry matter, MJ.

The energy of the growth of living mass is determined by the equations ARC (1984) [5]:

$$(B) = (220.73 \times DG + 28.64 \times DG2) \times LW.75, \quad (11)$$

$$(R) = (234.59 \times DG + 52.96 \times DG2) \times LW.75, \quad (12)$$

where: B gr. (б) - the net energy of growth of the body of Bugayts;

R gr (t) - the net energy of the growth of the body of the calves;

DG is the average daily gain of live weight.

Energy expenditure on motor activity was determined by the formula:

$$NE\ act = 0.42\ kJ / h / kgLW, \quad (13)$$

where: NE act - the net energy of activity;

LW - live weight.

The maintenance energy was determined by the ARC formula (1984) [2]:

$$CE\ under = 5.67 + 0.06 \times LW, \quad (14)$$

where: CE under - clean energy of maintenance.

USING THE BALANCE METHOD FOR PREDICTING THE ENERGY VALUE OF FEED AND RATION FOR CATTLE

The total energy content in the feed (gross, potential, gross energy) is determined by combustion of the sample in the oxygen medium of the calorimeter or on the basis of the chemical composition of the fodder in equation 3 or other.

In 1 kg of dry matter, the majority of plant fodder contains approximately 17-18.5 MJ of gross energy.

The amount of gross energy does not give an objective estimate of the amount of energy available for the animal. For example, in dry matter of straw there is almost the same amount of gross energy as in the dry matter of cereal grains (16.7-18.8 MJ), but the energy of the grains is available for animals, while its greater in straw remains unused. The energy of digestible nutrients of feeds and rations is determined for a particular species of animals. The following equation is recommended for cattle:

$$DE = 0.02424\ DP + 0.03412\ DF + 0.0185 + Dfiber + 0.017\ DNAM, \quad (15)$$

where: the amount of DE is expressed in MJ, and the digestible nutrients (protein, fat, fiber, non-nitrogen matters) in grams.

When assessing the quality of feed in laboratories, determining the content of digestive, exchange, or pure energy products use reference ratios of digestion, which leads to significant inaccuracies in the calculation of the content of the aforementioned energies. Here’s why, reference factors of digestibility of nutrients were established in many experiments under different conditions (level of feeding, nutritional value, type of feeding, etc.). Often digestion was determined on sheep or oxen and the results were mechanically transferred to all sex and age groups of cattle.

In Ukraine, in the departments of the quality control of forages, calculations are used for the digestibility of nutrients from the "Handbook of feeding nutrition", edited by M.M. Carpus

[3]. In the preface to this edition it is stated: "To determine the nutritional value of feeds, the coefficients of digestion are taken from the books of M.F. Tomme, R.V. Martynenko, K. Nering, N.P. Platikanov and other resources". M.F. Tomme (1964) in the preface to the book "The Fodder of the USSR" [4] states that "most of the coefficients are taken from domestic works partly borrowed from the book of Schneider "The Fodder of the World "(1947), from the German works of Cling, Franco and others. Sometimes they used predictive tables of digestibility of green fodder and hay at different contents of fiber".

This indicates that the digestibility factors in the reference books should be considered as very approximate. So according to various authors, the digestibility of corn grain energy is 74-91%. Another big difference between the digestion of certain nutrients of this feed.

Part of the errors is related to the study of the chemical composition of feed and feces. Feces of cattle after drying and grinding is a dust with a very small particle size that penetrates through a filter with a diameter of up to 0.1 mm, which is provided by the method of determining the crude fiber. In the feces, it is impossible to determine the content of calcium-bound fatty acids by the classical method of extraction. When drying under normal conditions, a part of nitrogen compounds airborne, etc. All this, obviously, leads to significant inaccuracies in determining the chemical composition of feces. Therefore, the most accurate is the calorimetry of feed and feces, which is done very rarely.

In the national reference literature, the digestibility of nutrients only of some feed is represented by the phase of vegetation, in most cases there is only the name of the feed, which, of course, leads to errors in determining the value of digestibility of nutrients of specific feeds, and therefore their energy assessment and evaluation of rations.

It will be more accurate to determine the coefficients of digestibility of one indicator energy than four. The coefficient of energy digestibility in grass, silage, haylage of bean grasses and bean-cereal mixtures, as well as in hay and grass meal made from any raw material can be determined by the formula:

$$CED = 88.9 + 0.015\ SP - 0{,}1\ SK, \quad (16)$$

Where: the RP and CF g / DM

DM – dry matter

To predict digestibility of grass energy, silage and haylage from cereal grasses and cereal-bean mixtures, we recommend the equation:

$$CED = 88.9 + 0{,}020\ RP - 0.085\ CF, \quad (17)$$

In straw and sex of all cultures, energy digestion can be determined:

$$CED = 88.9 + 0.035\ RP - 0.17\ CF, \quad (18)$$

Reference materials should be used for root crops, cereals, animal feeds, oil and extractive industry waste, as correlation between CED and RP and CF is unreliable.

These equations allow relatively precisely determine the coefficients of energy digestibility and can be successfully used in practical work in determining the nutritional value of feed by digestive and exchange energy. In this case, it is not necessary to use the index of digestibility factors, but determine them depends on the chemical composition of the feed, which is more objective and convenient in the work.

The coefficients of the digestibility of the energy of the rationcan be determined by the equation:

$$CED = 88.9 + 0{,}020\ RP – 0.09\ CF. \quad (19)$$

Thus, the content of digestible energy in the feed or diet should be determined by

$$DE = GE * CED. \quad (20)$$

As not all the energy of nutrients that disappeared in the digestive tract, gets into the internal environment of the organism in the form of products available for oxidation, and partly lost with gaseous fermentation products, then the energy available for exchange will be less than digestible.

The exchange energy (metabolic, physiologically useful, kinetic energy of the assimilated substances) - is defined as:

$$EE = GE - (EE+ UE + EG). \quad (21)$$

EE – energy of excrement

EG – energy of gases

In Ukraine, it is accepted to determine the content of exchange energy in feed for cattle, using the following equation:

$$EE = 0.01746\ DP + 0.03123\ DF+ 0.01365\ DFibre + 0.01478\ DNAM, \quad (22)$$

In the UK, the equation (ARC, 1984) [5] is used:

$$EE = 0{,}0152DP + 0{,}0342\ DF + 0.0128\ DFiber + 0.0159\ DNAM, \quad (23)$$

where the exchange energy in MJ, and the digestible nutrients in grams.

In the adopted Ukrainian equation, the calorimetric coefficients for protein and fiber are higher in voluminous feeds; the content of exchange energy is overestimated, especially in the haylage and straw.

In addition to the above equation for determining the content of EE in the norms ARC (1984) [5] recommends the following:

$$EE = 0.81 * DE \quad (24)$$

That is, the amount of EE in the feed or diet is 81% of digestive.

The presence of constants means that there is a constant interconnection between DE and EE, which is not true. At the same time, when in the experiments of O. Kelner it was proved that the productive effect of the feed is lower, the more it contains raw fiber.

Loss of energy with gases depends on many factors, and firstly on the amount of CF and lightly digested carbohydrates in the diet. In our studies, they contain about 12% of GE with fluctuations of 8-15% and can be predicted relatively objectively by equations 4 and 5.

If the energy loss with gases can be accurately determined, knowing the digestibility of nutrients, the energy loss in the urine is very weak correlated with the dry matter. The closest connection exists between the level of RP in the ration and the energy loss in the urine (r = 0.819) which can be determined by the equation 8.

Thus, we can recommend two systems of equations for evaluation the content of exchange energy in feeds and rations.

The first system of equations for the determination of EE through raw nutrients and the energy digestibility coefficient.

$$EE = GE \cdot CED - EG – UE \quad (25)$$

$$GE = 0.0238\ RP + 0.0397\ RZ + 0.0188\ CF + 0.0175\ RNAM \quad (26)$$

$$CDE = 88.9 + 0.020\ RP – 0.090\ CF \quad (27)$$

or other equation depending on the type of feed or reference data.

$$EG = 0.00544\ SC + 0.00222\ CNSE \quad (28)$$

$$UE = 0.0238\ RP + 0.15 \text{ or } UE = 0.00357\ RP. \quad (29)$$

In these equations GE, EE, EG, UE is determined in MJ, raw nutrients in grams in the natural forage, except for the definition of CED, where RP and CF in g / CF.

The second system of equations for determining the content of exchange energy through digestive nutrients using the nutrient digestibility ratios established in the experiments or taken from the reference.

$$EE = DE - EG – UE \quad (30)$$

$$DE = 0.02424\ DP + 0.03412\ DF + 0.01851\ DFiber + 0.017\ DNAM \quad (31)$$

$$EG = 0.00988\ DP + 0.0022\ DNAM \quad (32)$$

$$UE = 0.02424\ DP * 0.25 = 0.00606\ DP \quad (33)$$

In these equationsEE, DE, EG and UE are expressed in MJ, raw and digestible nutrients in grams in natural feed.

A comparative estimation of different methods for determining the content of EE suggests in favor of determining it according to the equations recommended by us. Experimental testing, which has been carried out in many experiments conducted over the past 20 years, confirms the reliability and accuracy of these equations. These approaches and techniques are completely published in the dissertation [5].

Biological and methodological approaches to heat balance.

The process of animal life is accompanied by the continuous heat formation in its body and the generated heat outback to the environment. An animal's organism is a self-regulated system with an internal source of heat, in which under normal conditions, heat production - the amount of generated heat - is equal to the amount of heat given to the environment. The internal temperature of the skin is constant due to the regulation of the intensity of heat production and heat transfer, depending on the temperature of the external environment. The skin temperature of the animal under the influence of external conditions varies in relatively broad limits.

The thermal equilibrium between the animal's organism and the environment is a condition of comfort, which depends on the temperature of the environment, the walls and surfaces of the surrounding objects, the speed of the air, the humidity of the air, the nature of the hair and the value of the heat production of the animal. This quantity, in turn, depends on the age, sex of the animal, its feeding, muscular activity and other factors. For example, with a decrease in the temperature of the external environment, with the intake of food and the subsequent processes of digestion, with muscular work, heat production is increased to achieve a thermal equilibrium with the environment because of increased chemical reactions of metabolism.

The amount of energy consumed by the animal before eating at full muscle rest at an optimum temperature of the external environment, which corresponds to the minimum activity of the mechanism of thermoregulation, is the main (standard) exchange. Experimentally, the heat production of an animal is usually determined by direct and indirect calorimetry.

Heat in the animal's organism (in cells) is formed in the process of complex biochemical reactions (oxidation) of biological metabolism. The organ of heat formation is the whole organism as a whole, which works on the basis of definitely reflex mechanisms - in a state of rest and reflex - in muscle activity.

Heat production and heat transfer are due to the activity of the central nervous system, which regulates metabolism, blood circulation, sweating and the activity of skeletal muscles.

Heat transfer is the process of returning heat to the animal is carried out through heat conduction (conduction), convection (conduction), radiation (radiation), breathing and evaporation of sweat and moisture from the lungs. A significant amount of heat is spent on heating fodders and water, heating air in the lungs.

Thermal conductivity (conduction) is the heat transfer from the surface of the animal's body to solid objects is carried out to floors, earth, walls, milking equipment, etc.

The transfer of heat in this case follows the Fourier Law:

$$Qkond = K \cdot F (t1 - t2) \cdot [kcal / h], \quad (34)$$

where: Qkond - return of heat through conduction;

F - contact surface of the animal with the object, m2;

t1 - temperature of the surface of the body, ° C;

t2 - temperature of the body surface of the touch, ° C;

K - coefficient of heat transfer, equal.

$$K = 1 / (Y [d / b] TC + Y [d / b] p.) \cdot [kcal / m2 \cdot h \cdot hail], \quad (35)$$

where: b - coefficient of thermal conductivity, kcal / m • h • hailstones;

d - the thickness of the hair (and litter), m.

The heat transfer of the conduction through the air is very small, since the coefficient of thermal conductivity of stationary air is 0.00083 kcal / cm • sec • h • deg.

Convection involves the transfer of heat from the body surface of the animal to the air moving around it. In the overall balance, the heat loss of heat transfer by convection constitutes a significant proportion (over 25-30%).

For calculations of heat transfer by convection one can use the equation of N.K. Witte, based on the calculation of the cooling of the catatermeter and the empirical constant values established at the same time:

$$C1 = 0.10 (0.5 + \sqrt{v}) \cdot P \cdot (Tv - Tp) \text{ for } v \leq 0.6 \text{ m / sec}; \quad (36)$$

$$C2 = 0.12 (0.273 + \sqrt{v}) \cdot P \cdot (Tv - Tn) \text{ for } v > 0.6 \text{ m / s}, \quad (37)$$

where: C1, C2 - heat transfer by convection;

v - velocity of air, m / sec;

P - the surface of the body of an animal involved in heat exchange, m2;

TV - air temperature, ° C;

Tp - temperature (average) of skin surface, ° C

Radiation heat transfer is the transfer of heat in the form of radiant energy from the animal's body surface to the surrounding space. The amount of heat emitted by radiation depends on the temperature of the body surface, the temperature surrounding the body of the walls and surfaces, their ability to provide heat, the size of the body surface and surrounding surfaces, the distance and the relative position of the body and the surrounding surfaces.

Heat transfer through the radiation in the state of rest of the animal is 43-50% of the total heat loss.

Radiation of an animal's body is characterized by a wavelength from 5 to 40 microns, and the animal's skin absorbs infrared rays as a completely black body. The amount of heat emitted by the unit of the body surface per unit time is determined by the law of Stefan-Boltzmann, which is valid only for absolutely black and gray bodies:

Qrad = C • Fizl • [(273-tn / 100) 4 - (273 + to / 100) 4] • [kcal / h], (38)

where: c - coefficient of mutual radiation, kcal / m2 • h • hailstones;

Fisl - radiates the surface of the human body, m2;

tp - temperature of the surface of the body and clothing, ° C;

to-temperature of surrounding surfaces, ° C.

This law shows that the intensity of radiation increases dramatically with an increase in the temperature of the surface of the body.

In the room, the heat dissipation is determined by the formula N. Witte:

Qr = 0.093 • P • (TST - TT) • [kcal / min], (39)

where: Qr - heat dissipation, kcal / min;

P - surface of the human body, m2;

Tst - the temperature of the walls;

Tt is the average body temperature.

In human heat exchange, convection and radiation participate in an average of 75% of the entire body surface.

When evaporation of sweat from an animal's body is collected by heat, which is a hidden heat of steaming. The process of heat transfer by evaporation from the surface of the skin and animal lungs in the conditions of comfort is 23-29% of the total heat output.

The amount of heat emitted from the surface of the body by evaporation is determined by the equation:

Qn = bB • W • F (PK - PB) • [kcal / h], (40)

where: WF - part of the body surface, covered with sweat, m2;

W - coefficient of skin moisture ≈ 0.2-1;

PC - partial pressure of water vapor in saturated air, mm Hg over the skin;

PB is the partial pressure of water vapor in the ambient air, mm Hg. st .;

bB - coefficient of heat transfer to the external environment during evaporation of sweat (kcal / m2 • h • mm),

$$bB = 1.25 K, \quad (41)$$

where K - coefficient of heat transfer,

$$bB = 10.45 + 8.7 v, \quad (42)$$

where: v - air velocity.

As can be seen from the equation, the amount of sweat that evaporates depends on the velocity of the air, the surface area of the body covered with sweat, and on the difference of partial pressures (Pk-PB); which varies depending on temperature and relative humidity of air. The intensity of water vapor separation from the skin of a person sharply increases and with intense muscular activity of the animal.

With approximate calculations, there is an amount of heat released from the surface of the skin by evaporation, mainly depends on the amount of evaporated moisture and the temperature of the skin.

The amount of heat given by the body of the animal to heat the air in the lungs depends on the amount of air and its temperature at the entrance and exit of the body. In addition, the amount of heat given to the evaporation of moisture depends on the amount of air that passed through the lungs when breathing and on the moisture content of the inhaled and exhaled air. It is determined by the formula

$$Q = 0.001 mp, \quad (43)$$

where: p - specific heat of evaporation of water, kcal / year;

m - amount of moisture evaporated in lungs kcal / h; is determined by the difference in moisture content in inhaled and exhaled air.

The question of the influence of ambient temperature on the energy exchange and the need for animals in it is largely obstructed by the lack of a methodological basis for such an analysis. Therefore, in most studies, the description of the conditions for carrying out the experiment is neglected, which makes it impossible to summarize the data and draw conclusions.

There is no doubt that the temperature of the air, food, water and materials where the animals restoreis influenced by the need for animals in energy due to the thermoregulation.

Take a factor like the temperature of inhaled animal air and determine how much heat is needed in order for the animal to heat the air to the body temperature. In 19 physiological experiments, it was found that young cattle for a day inhale about 200-250 l of air per 1 kilogram of body weight. A live weight of 500 kg ox per day will inhale 100-125 m3 of air. To determine the energy requirement for heating such air we use the following equation:

$$Qpp = 1{,}293V\ (Tt - Tp) \qquad (44)$$

where: Qp - the amount of heat needed to heat the air, KJ

V - amount of air inhaled that day m3,

C - heat capacity, KJ

T - air temperature

T body - body temperature of animals.

The ox at a temperature difference of 20 ° C (between air temperature and body temperature) of 2.5-3.2 MJ of feed energy at a temperature difference of 30 ° where there will be 3.9-4.8 MJ.

Another aspect is the heating of food and water to body temperature.

Let the ox of live weight 500 kg consume 50 kg of juicy feed of the mixture and water per day. To heat this amount of substances at 20 ° C, 4.2 MJ of feed energy is required, at 30 ° C to 6.3 MJ.

$$Qq = 4.1868\ mx\ (Tt - Tc) \qquad (45)$$

where: Qq - amount of energy needed to heat food and water,

KJ Tt - body temperature

Tc - temperature of feed and water,

M -the mass of juicy food and water.

So, only air, food and water carrying air to the body temperature of a live ox weighing 500 kg with a temperature difference of 20 ° C require 6,7-7,4 MJ of feed energy, and at 30 °C, respectively, 10,2-11,1 MJ, which accounts for more than 10% of the animals' demand for exchange energy.

Therefore, it is imperative to take into account the temperature of air, water and feed during research.

Thermoregulation is a set of physiological processes that maintain the internal temperature of the body at a constant level. Heat formation depends on the intensity of the chemical reactions of the metabolism, whose growth at the cooling of the body is provided by chemical thermoregulation. Physical thermoregulation regulates the return of heat by the body through physical processes: heat conduction, convection, radiation and evaporation.

Chemical thermoregulation is carried out by changing the intensity of oxidative processes caused by micro-vibration of the muscles (oscillations); and physical - a change in skin temperature, due to the expansion (narrowing) of the skin vessels, changes in the intensity of sweating and respiration, which is a reaction to changes in the temperature of the environment, humidity and other factors. Expansion of the vessels of the skin and an increase in the amount of blood that flows leads to increased heat dissipation, narrowing them - to reduce it. Thermoregulation occurs reflexively due to irritation of the temperature receptors of the skin and mucous membranes, the emergence of nerve impulses that excite the nerve centers.

In the process of constant metabolism in the animal's body, as a result of the decomposition of complex chemical compounds, energy is released. It transforms into thermal, electrical and mechanical energy and provides the flow of all forms of activity of the organism. Proceeding from the 1st and 2nd laws of thermodynamics, the energy balance of an animal's organism can be described by the equation:

$$TP + J = Qrad. + Qcon + Qvip. + Qdich + QPP + Qqv, \quad (46)$$

where: M - energy produced in an animal's organism (heat production);

Qrad - Heat loss by radiation

Qcon - loss of heat by heat conduction and convection;

Qvip - heat loss by evaporation of moisture from the skin and upper respiratory tract;

Qdich - heat loss on heating of inhaled air;

QP - the amount of heat needed to heat the air;

Qq - amount of energy needed to heat food and water;

J - adsorption of heat by radiation (for example, solar).

CONCLUSION

1. In conducting experiments and prediction of the energy balance for ruminants, it should be understood that at the same time there will be indicative indicators, since in the animal scar, along with the processes of digestion of nutrients, there is a synthesis that is difficult to determine absolutely precisely.
2. In addition to the list of energy expenditures, it is necessary to remember that there are significant energy expenditures for bringing the temperature of water and feed to the body temperature of animals, energy expenditure on wool growth and seasonal laziness, the growth of horns and hoofs, and the like. 3. Our proposed methods have been tested mainly on young animals of cattle, so it is advisable to check on adult animals under different physiological conditions.
3. The methods proposed by us were tested mainly on young cattle; therefore, it is expedient to make a check on adult animals of different physiological conditions.

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