Journal of Tropical Animal Research(Renamed as Indian Journal of AgriVet Research)
Volume 1, Issue 3, 2021, Pp. 113-119
Available online at https://aavpublisher.com
ISSN: XXX-XXX

ORIGINAL ARTICLE

Effects of Body Composition at Pre-natal and Post-natal stages in Livestock

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Article Received: 22.03.2021 *Article Published: 25.03.2021*

ABSTRACT

Body composition of animals at prenatal and post natal stages is very necessary part of life. At prenatal stages fetus growth consist of more water, protein in their body and composition changes with the advancement of age of animal. All major milestones of animal development are accomplished inside the uterus, which is profoundly affected by maternal nutrition. The fetal stage sets the trajectory for long-term growth of farm animals. Skeletal muscle and adipose tissue are the most susceptible to maternal nutritional and physiological fluctuations. Nutrient deficiency during late gestation and neonatal stages, when adipose tissues are actively developing, reduces overall fat cell formation including intramuscular fat (marbling). The long duration of pregnancy and lactation stage of growing animals provides unique advantages for stage-specific nutrient supplementation, achieving precision animal production management to improve animal production efficiency and quality.

Keywords: Body composition, nutrition, neonatal stages, pregnancy and lactation stages

INTRODUCTION

Knowledge of body composition of animals at prenatal and post natal stages is necessary in nutritional and clinical studies. The famous English scientists **Jonh B. Lawes** and **Joseph H. Gilbert (1859)** analyzed the composition of entire bodies of farm animals. Body composition made up of several nutrients such as water, protein, energy in the form of carbohydrates and fats. At prenatal stages fetus growth consist of more water, protein. On an average, an adult animal body contains 60% water, 18 % protein, 18% fat and 4% ash. Whereas on fat free basis (protoplasmic basis) gross composition of animal body is 73% water, 22% protein and 5% ash. On water and fat free basis gross composition of the animal body is 80% protein and 20 % ash.

ROLE OF WATER

Water is the one of the most vital for all nutrients. The water content of the animal body varies with age. The newborn animal contains 75–80% water but this falls to about 50 % in the mature fat animal.

It is vital to the life of the organism that the water content of the body be maintained: an animal will die more rapidly if deprived of water than if deprived of food. Water accounts about two-fifth (40%) to four-fifth (80%) of the entire weight of the animal body.

The percentage of water is affected by various conditions, of which age is the major factors. The proportion of water is highest at the prenatal stage and decreases after birth and lowest in old stages. The new born animals have about 75-80 % of water whereas mature animal contains 55% water.

S.No.	Bovine	Water percentage	Human	Water percentage
1.	Embryo	90	Embryo	93
2.	New born calf	80	New born infant	72
3.	6-12 month	65	2 month infant	70
4.	Adult steer	55	Adult	60

Percentage Composition of the Animal Body:

						DRY, FAT FREE BASIS	
S.NO.	SPEICIES	WATER	PROTEIN	FAT	ASH	PROTEIN	ASH
1.	Calf newborn	74	19	3	4.1	82.20	17.80
2.	Calf, fat	68	18	10	4.0	81.60	18.40
3.	Steer, thin	64	19	12	5.1	79.10	20.90
4.	Steer, fat	43	13	41	3.3	79.50	20.50
5.	Sheep, thin	74	16	5	4.4	78.20	21.80
6.	Sheep, fat	40	11	46	2.8	79.30	20.70
7.	Pig, 8 kg	73	17	6	3.4	83.30	16.70
8.	Pig, 30 kg	60	13	24	2.5	84.30	15.70

9.	Pig, 100 kg	49	12	36	2.6	82.40	17.60
10.	hen	56	21	19	3.2	86.80	13.20
11.	Rabbit	69	18	8	4.8	79.10	20.90
12.	Horse	61	17	17	4.5	79.20	20.80
13.	Man	59	18	18	4.3	80.70	19.30

WATER FUNCTIONS IN ANIMAL BODY SYSTEM

- In the body as a solvent in which nutrients are transported about the body and in which waste products are excreted. Many of the chemical reactions brought about by enzymes take place in solution and involve hydrolysis.
- Because of the high specific heat of water, large changes in heat production can take place within the animal with very little alteration in body temperature.
- Water also has a high latent heat of evaporation, and its evaporation from the lungs and skin gives it a further role in the regulation of body temperature.

SOURCES OF WATER

The animal obtains its water from three sources:

- Drinking water,
- water present in its food
- Metabolic water: This last being formed during metabolism by the oxidation of hydrogen-containing organic nutrients.
- Metabolic water is also produced by the dehydration synthesis of body protein, fats and carbohydrates.

Body water can be determined by dilution techniques. These techniques involve the injection of Antipyrine and its analogs and water containing radioactive isotope of deuterium and tritium for determination of water concentration.

ROLE OF FAT

Fats are important components of animals. Adipose tissue deposition in case of animals is affected by the genetic factors, gender age, nutritional status, ambient temperature, physical activity disease and stress. The percentage of fat normally increases with age. The fat content of body is highly variable, depending upon the level of food intake. Its variation affects the percentage of other constituents. There is an inverse relationship between the concentration of water and of fat in the body.

- The fat content of animal body can be calculated from the measured water

  As **$Y= 355.88\,X- 202.91\log X$,** where Y= percent fat content and X= percent water content.

Body fat can be determined by densitometry method. In this method the volume of animal is measured by displacement when it is submerged in water. This method is more applicable to animal carcasses than to live animals.

ROLE OF CARBOHYDRATES

In case of animal, percentage of carbohydrate is being ignored since it accounts for less than one percent of the body.

ROLE OF PROTEIN

In animals, proteins are present in every animal cell and such are principal constituent, other than water, of the organs and soft structures of the body such as muscles, tendons and connective tissues. Lean body mass (i.e. empty body weight less weight of fat) can be estimated using K^{40} isotope to calculate protein.

ROLE OF ASH

Calcium and phosphorus are the major inorganic components present in largest amount in body, is present almost entirely in the bones and teeth as phosphate and hydroxide. The phosphorus which is combined with calcium to form the skeleton accounts for approximately 80 percent of body supply. Sulphur occurs throughout the body as a part of protein molecule. Sodium, potassium and chlorine are present almost entirely as inorganic salts in the various fluids. Most of the of animals, whereas potassium and silicon are the main inorganic elements in plants. Vitamins are present in animals in small quantities. Animals have limited powers of synthesis of vitamin synthesis, and are dependent upon an external supply.

S.NO.	Maternal stressor	Systems and processes affected
1.	Overfeeding of adult dams	Body composition, growth, energy balance, adipose, endocrine, gastro-intestinal tract, muscle, placenta, gonads
2.	Underfeeding of adult dams	Adipose, brain, cardiovascular, endocrine, gastrointestinal tract, kidney, muscle, placenta
3.	Multiple pregnancy	Behavior, endocrine, placenta
4.	Specific nutrients (e.g., protein, Se, etc.)	Body composition, growth, endocrine, gastro-intestinal tract, placenta, gonads

Systems and bodily Processes affected in the fetus and offspring duing late Pregnancy/ Postnatally in a variety of animal models.

Some studied said that, in humans and animal models, offspring of mothers who experience nutrient restriction early in pregnancy but receive adequate nutrition later in pregnancy, resulting in normal birth weights, still exhibit many of the same phenotypes as offspring from mothers that are undernourished for the whole of pregnancy. These phenotypes include poor growth, increased adiposity, poor glucose tolerance, and dislipidemia. (Barker, 2004; Ford et al., 2007; Vonnahme et al., 2007; Dong et al., 2008).

These and similar observations emphasize the importance of interventions designed to correct the developmental defects during fetal or early postnatal life, because if the organ systems are indeed programmed, then later interventions may be much less effective.

Further some other researchers also emphasize the importance of nutrients during gestation period. For example, in humans and animal models, rapid body weight gain during gestation further impairs body composition, leading to obesity in the offspring and new born animals. (Barker, 2004, 2007; Reynolds et al., 2010b).

Maternal nutrient deficiency negatively affects fetal development, which has long-term negative impacts on offspring growth performance (Funston et al., 2010a; Du et al., 2013; Robinson et al., 2013). On the other hand, nutrient supplementation promotes fetal development, especially muscle development due to its low priority in nutrient partitioning, improving lean:fat ratio and overall production efficiency of offspring (Du et al., 2010).

Meat animals such as goat, sheep, beef cattle, pigs are raised primarily for their lean meat, which is mainly composed from muscle fibers, intramuscular fat (marbling fat), and connective tissues. Muscle fiber development can be roughly separated into prenatal and postnatal stages.

For livestock, all muscle fibers are formed before birth, and postnatal muscle growth is due to increase in the diameter and length of existing muscle fibers. Thus, increasing muscle fiber formation during fetal development enhances muscle mass in offspring. Sufficient maternal nutrition during mid-gestation, especially proteins, promotes formation of muscle fibers.

Beside muscle, adipose tissue development is also profoundly affected by maternal nutrition. There are four fat depots in animals: visceral, subcutaneous, intermuscular and intramuscular fat, of which, only intramuscular fat (marbling fat) is critical for meat palatability. In beef cattle, visceral and subcutaneous fat mainly develop during the mid-gestation to neonatal stage, which is slightly before the development of intramuscular adipocytes (fat cells). Enhancing intramuscular adipocyte formation during the late gestation and neonatal stages provides sites for intramuscular lipid accumulation during fattening, increasing marbling.

The amount of fat mass is determined by the number and size of adipocytes. The number of adipocytes is primarily determined during the fetal and early postnatal development and the total number of adipocytes becomes fixed at adolescence (Spalding et al., 2008). Therefore, the early developmental stage is ideal for altering adipocyte formation (Du et al., 2015); the desirable outcome is to have more intramuscular adipocytes while reducing adipocyte formation in other depots.

The major formation of adipocytes occurs during late gestation to early weaning stages. Thus, maternal nutritional management during this period affects adipocyte hyperplasia, which alters overall adipose tissue development as well as intramuscular adipocyte density and thus marbling fat (Du et al., 2013).

Nutrient supplementation during the early- to mid-gestation of bovine pregnancy has the potential to improve muscle development and lean:fat ratio of offspring. Developmental programming can also be extended to the postnatal management of cattle, for example, through enhancing milk production of cows or supplementation of high-energy starters to early weaning calves to enhance marbling fat development. Maternal milk composition is altered by maternal diet, providing another opportunity to alter neonatal nutrition, and thus, offspring development and subsequent meat production. Indeed, maternal high-energy intake during lactation affects milk composition, which has long-term effects on the metabolic health in offspring mice (Vogt et al., 2014). We found that maternal over-nutrition during lactation promotes adipose development in mice (Liang et al., 2016).

CONCLUSION

The profound impact of maternal nutrition on fetal development has been well established, of which fetal body composition, skeletal muscle and adipose tissue development are particularly vulnerable due to their low nutrient partitioning priority compared with vital organs and tissues. Because meat animals are raised primarily for their meat production, improving maternal nutrition during gestation, especially during the periods corresponding to major muscle and intramuscular fat development, will improve fetal muscle and adipose tissue development, which has long-term impacts on the production efficiency in offspring, animals. The long duration of pregnancy and lactation stage of beef cattle, dairy animals, provides unique advantages for stage-specific nutrient supplementation, achieving precision animal production management to improve animal growth, production efficiency and quality.

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