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Comparative of digestive physiological in poultry and ruminant

A Graduation Research Project,the research paper provides a comprehensive examination of the digestive physiology of poultry and ruminants

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بسم الله الرحمن الرحيم

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Abstract

This research paper provides a comprehensive examination of the digestive physiology of poultry and ruminants, focusing on anatomical structures, digestive processes, microbial fermentation, nutrient absorption, and metabolic adaptations. By elucidating the similarities and differences between these two groups of animals, this study aims to enhance our understanding of their dietary requirements and optimize feeding strategies for improved productivity and health. Understanding the intricate digestive physiology of poultry and ruminants is crucial for optimizing their nutrition, health, and production efficiency. This comparative analysis delves into the fundamental differences and similarities between these two classes of animals. Poultry, characterized by a simple monogastric digestive system, primarily rely on enzymatic digestion and rapid transit time for nutrient absorption. In contrast, ruminants possess a complex foregut fermentation system, facilitating the breakdown of fibrous plant materials through microbial fermentation. This abstract highlights key aspects such as anatomical structures, digestive enzymes, microbial populations, and nutrient utilization strategies unique to each group. Insights from this comparison offer valuable implications for animal nutritionists, veterinarians, and researchers aiming to enhance the efficiency and sustainability of poultry and ruminant production systems.

INTRODUCTION

1.1 **Overview**

vertebrates need to achieve the same end point, which is to convert food into constituent mol-ecules (i.e., free fatty acids, monosaccharides, amino acids, etc.) that can be absorbed to be used as struc-tural molecules and energy substrates and to absorb other essential components, such as vitamins and ions. How each species reaches this end point and the ways in which they enlist microbiota to aid the tasks differ. Differences in digestive physiology are important in determining, inter alia, the diet appropri-ate to a particular species, how broad a range of foods an animal can eat, the efficiency of conversion, and food tolerances. Even within a species, the appropri-ate diet depends on life stage and animal condition (e.g., differing between preparturition and lactation in dairy cattle). Conversion efficiency is an important consideration for agriculture, in which animal feed is an input cost. In the development of nutritional strate-gies to improve conversion efficiency, most attention has been paid to the metabolism of farm animals to processes happening within the lumen of the digestive tract. The primary interest was to optimize the purely digestive process without considering the gut as a target organ per se. With recent progress of technologies and subsequent new knowledge generated by biological sciences, there is an increased interest in physiological processes that occur in the digestive tract. The gut is now considered to be an intelligent sensory organ controlling physiological functions of zootechnical importance. Undoubtedly, knowledge and progress are quicker in other fields of biology compared with animal nutrition. The relatively slow progress reinvigorates the quest for better knowledge of digestion and absorption in animals and also for improved understanding of comparative aspects among species.(2015 American Society of Animal Science)

Literature Review

2.1 Digestive system in ruminant

Anatomy of the ruminant digestive system includes the mouth, tongue, salivary glands , esophagus, four-compartment stomach (rumen, reticulum, omasum, and abomasum), small intestine (duodenum, jejunum, and ileum), and large intestine (cecum, colon, and rectum).

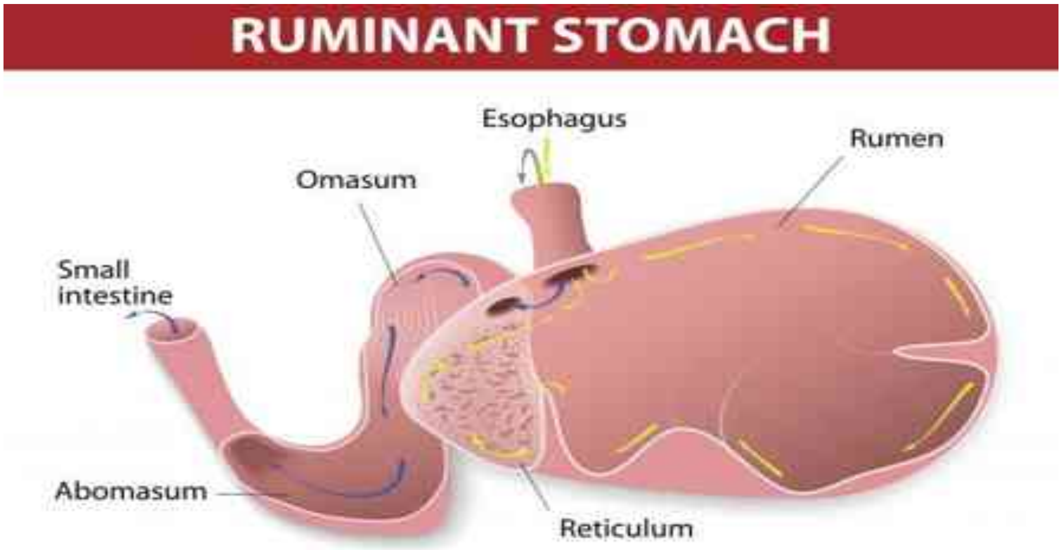
1.Mouth and Tongue: Ruminants use their mouths and tongues to harvest forages during grazing or to consume harvested feedstuffs. The tongue wraps around plants and tears them for consumption. The mouth lacks incisors on the upper jaw, with lower jaw incisors working against a hard dental pad.

2.Salivary Glands: Saliva is produced by salivary glands and serves multiple functions. It aids in chewing and swallowing, contains enzymes for fat and starch breakdown, and is crucial for buffering rumen pH. Saliva production is stimulated by chewing feed.

3. Esophagus: The esophagus is a tube-like passage that carries feed and saliva from the mouth to the reticulum. It functions bidirectionally, allowing ruminants to regurgitate cud for further chewing.).(Jane Parish – Extension Beef Cattle Specialist, Mississippi State University, 2011)

4.Stomach

Rumen, Reticulum, Omasum and Abomasum: Ruminants have a four-compartment stomach



01 (Ruminant stomach) figure.

I.Rumen: Also known as the "paunch," the rumen is the largest compartment of the ruminant stomach, occupying a significant portion of the abdominal cavity. It is lined with papillae, which increase surface area for nutrient absorption. The rumen acts as a fermentation vat, hosting a diverse population of microorganisms that break down plant material through microbial fermentation. This process produces volatile fatty acids (VFAs), gases (such as methane), and other byproducts. The VFAs are absorbed across the rumen wall and serve as an energy source for the animal .
(Jane Parish, Extension Beef Cattle Specialist,2011)

Interior lining of the rumen, revealing papillae in an 8-week-old calf.

02 (Rumen) figure.

II. Reticulum: The reticulum is often referred to as the "honeycomb" due to its distinctive honeycomb-like lining. It sits underneath and toward the front of the rumen, lying against the diaphragm. Ingesta flow freely between the reticulum and rumen. The main function of the reticulum is to collect smaller digesta particles and move them into the omasum, while larger particles remain in the rumen for further digestion. Additionally, the reticulum serves as a trap for heavy or dense objects, such as nails or wires, that the animal may consume. This helps prevent such objects from causing harm by collecting in the reticulum rather than passing through the digestive tract . (Jane Parish, Extension Beef Cattle Specialist,2011).

"Honeycomb" interior lining of the reticulum in an 8-week-old calf.

03 (Reticulum) figure.

III. Omasum: The omasum is a spherical compartment connected to the reticulum by a short tunnel. It is often referred to as the "many piles" or the "butcher's bible" due to the numerous folds or leaves in its lining, resembling pages of a book. These folds increase surface area, facilitating nutrient absorption. Water absorption also occurs in the omasum. Cattle, in particular, have a highly developed omasum. (Jane Parish, Extension Beef Cattle Specialist,2011)

Interior lining of the omasum, revealing the "many piles" tissue folds in an 8-week-old calf.

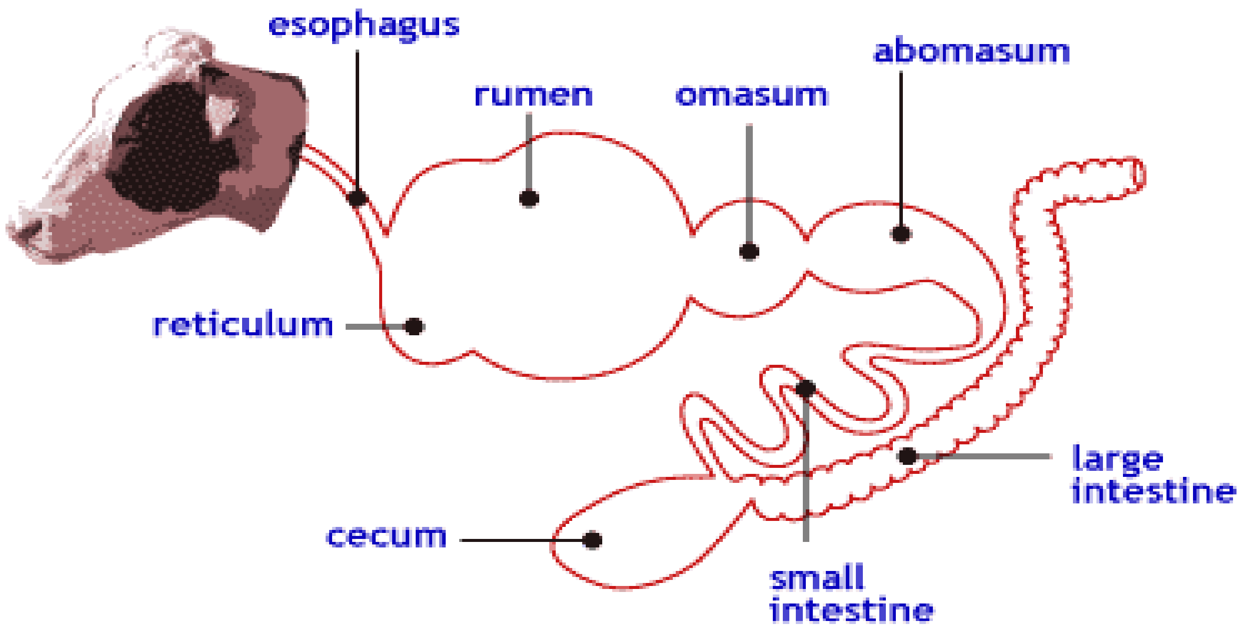
04 (Omasum) figure.

IV. Abomasum: The abomasum is the "true stomach" of the ruminant, most similar to the stomach of non-ruminant animals. It produces hydrochloric acid and digestive enzymes, such as pepsin, which break down proteins. The abomasum also receives digestive enzymes secreted from the pancreas, aiding in digestion. This compartment has a lower pH compared to the rumen and reticulum, typically ranging from 3.5 to 4.0. The abomasum plays a crucial role in preparing proteins for absorption in the intestines .(Jane Parish, Extension Beef Cattle Specialist,2011)

Interior lining of the abomasum, the "true stomach," in an 8-week-old calf.

05 (Abomasum) figure

Each compartment of the ruminant stomach serves distinct functions in the digestive process, collectively enabling ruminants to efficiently utilize fibrous plant material as a source of nutrients. Understanding the roles of the rumen, reticulum, omasum, and abomasum is essential for optimizing ruminant nutrition and health



06(divestive system of cow) figure

5.The small intestine in ruminants is an essential part of their digestive system, responsible for further digestion and absorption of nutrients.

I. Duodenum: The first segment of the small intestine where partially digested food from the stomach (rumen, reticulum, omasum, and abomasum) enters. Bile from the liver and digestive enzymes from the pancreas are secreted into the duodenum to aid in the breakdown of fats, proteins, and carbohydrates.

II. Jejunum: The middle segment of the small intestine where most of the chemical digestion and nutrient absorption take place. The inner surface of the jejunum is lined with villi and microvilli, which increase the surface area for absorption of nutrients such as sugars, amino acids, and fatty acids into the bloodstream.

III. Ileum: The final segment of the small intestine where further absorption of nutrients occurs, especially vitamin B12 and bile salts. The ileum connects to the large intestine (colon) through the ileocecal valve, which regulates the flow of digesta between the small and large intestines.

Overall, the small intestine in ruminants plays a crucial role in breaking down food particles into smaller molecules that can be absorbed and utilized by the body for energy, growth, and maintenance. Its efficient absorption surface and enzymatic activity contribute to the animal's overall health and productivity. Let me know if you need more specific information about any aspect of the small intestine in ruminants.**(**Jennie Eilerts,How does the digestive system work in cow,2019**)**

6.The large intestine in ruminants plays a vital role in further digestion, water absorption, and fermentation of fibrous material.

II. Cecum:

- The large intestine begins with the cecum, a blind sac located at the junction of the small and large intestines.
- In ruminants, the cecum is relatively small compared to non-ruminant herbivores but still serves as a site for fermentation of fibrous material and absorption of water and electrolytes.

III. Colon:

- The colon follows the cecum and consists of several segments: ascending colon, transverse colon, and descending colon.
- The colon primarily functions in the absorption of water and electrolytes from the digesta, helping to concentrate the ingested material and form feces.

III. Fermentation:

- Microbial fermentation continues in the large intestine, particularly in the colon, where remaining fibrous material is further broken down by resident bacteria.

- Fermentation in the large intestine produces additional volatile fatty acids (VFAs), which contribute to the animal's energy requirements.

IV. Water Absorption:

- The large intestine absorbs water from the digesta, reducing its moisture content and forming solid fecal matter.

- Efficient water absorption helps to maintain hydration and prevent dehydration in ruminants.

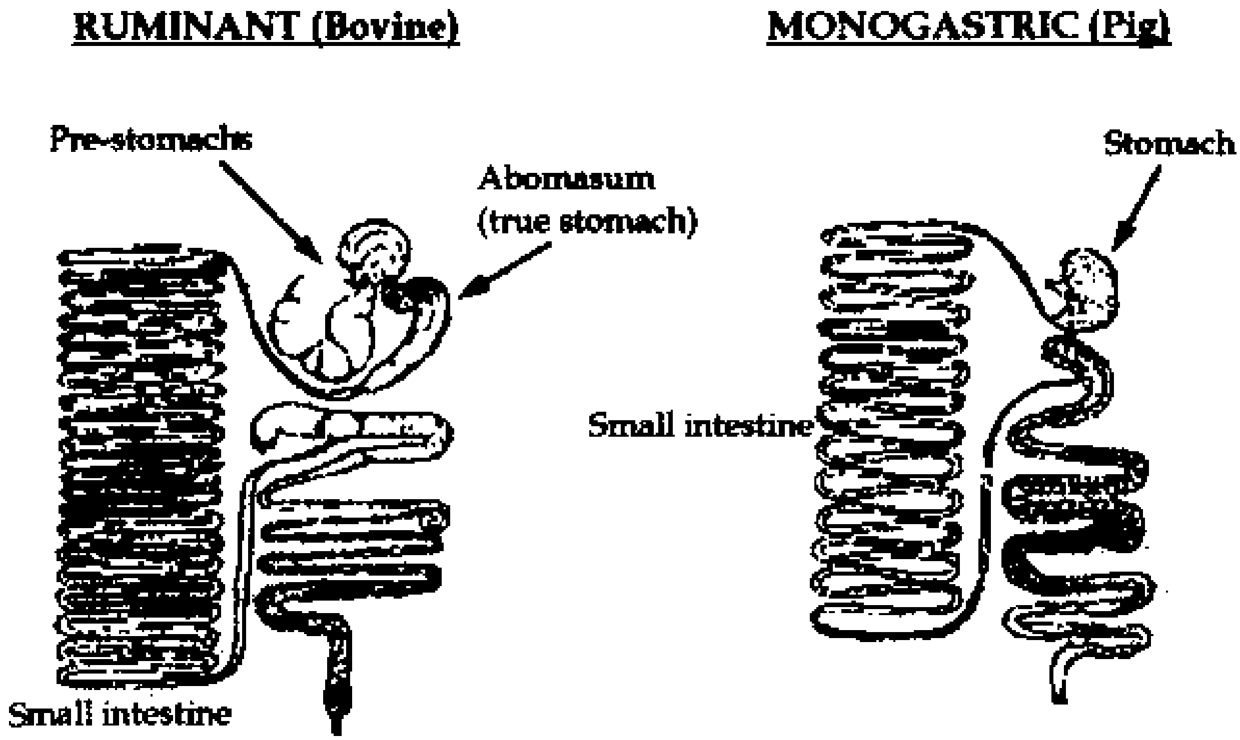
V. Fecal Formation:

- As the digesta moves through the large intestine, water is gradually absorbed, and the remaining material is compacted into fecal pellets.

- Fecal pellets are expelled from the body through the anus during defecation, completing the digestive process.

the large intestine in ruminants plays a crucial role in further digesting fibrous material, absorbing water and electrolytes, and forming feces for excretion.

(Quantitative aspect of ruminants digestion and metabolism,2018)



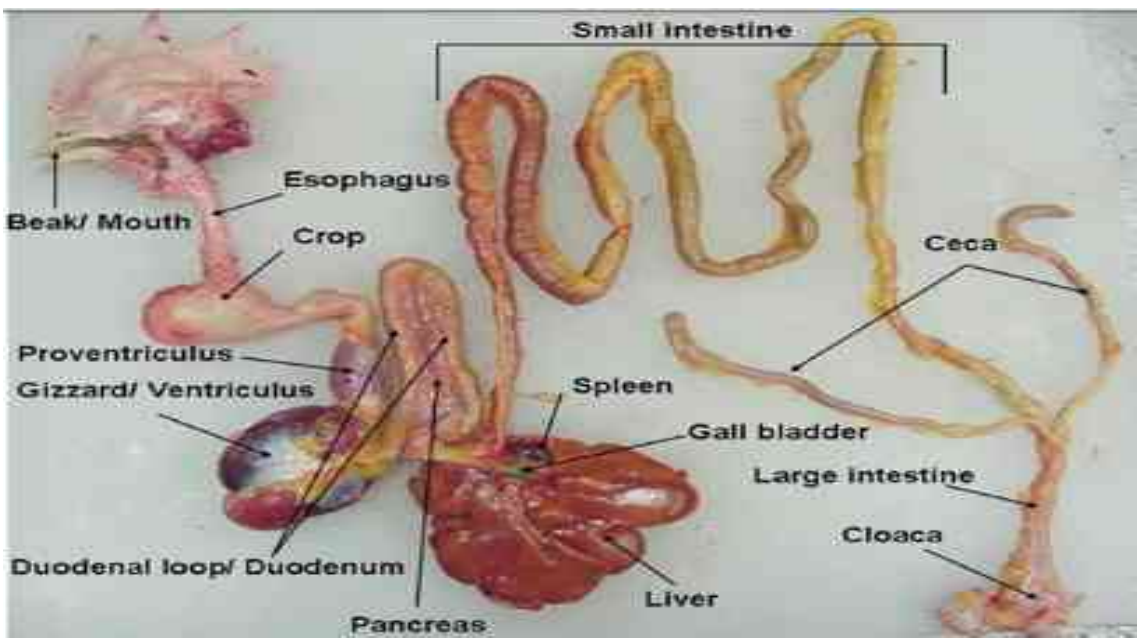
07 (Ruminant and Monogasrtic stomaches) figure

2.2.1 Avian Digestive System

An understanding of the avian digestive system is essential for developing an effective and economical feeding program for your poultry flock and for recognizing when something is wrong and taking necessary actions to correct the problem.The digestive system of any animal is important in converting the food the animal eats into the nutrients its body needs for growth, maintenance, and production (such as egg production). An animal's body breaks down food through both mechanical and chemical means. In many animals, the mechanical action involves chewing; however, because birds do not have teeth, their bodies use other mechanical action. The chemical action includes the release of digestive enzymes and fluids from various parts of the digestive system. After being released from food during digestion, nutrients are absorbed and distributed throughout the animal's body. (Dr. Jacquie Jacob, University of Kentucky)

2.2.2 Parts of a chicken digestive tract

The chicken has a typical avian digestive system. In chickens, the digestive tract (also referred to as the gastrointestinal tract or GI tract) begins at the mouth, includes several important organs, and ends at the cloaca. Figure 1 shows a chicken digestive tract, and Figure 2 shows the location of the digestive tract in the chicken's body. (Dr. Jacquie Jacob, University of Kentucky)

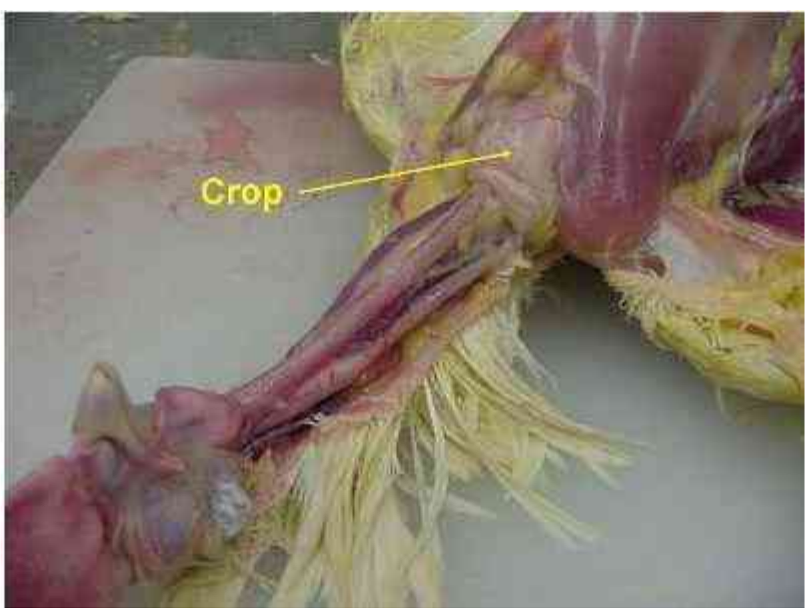


08 (Chicken digestive system I) figure

09 (Location of the digestive tract in a femalechicken) figure

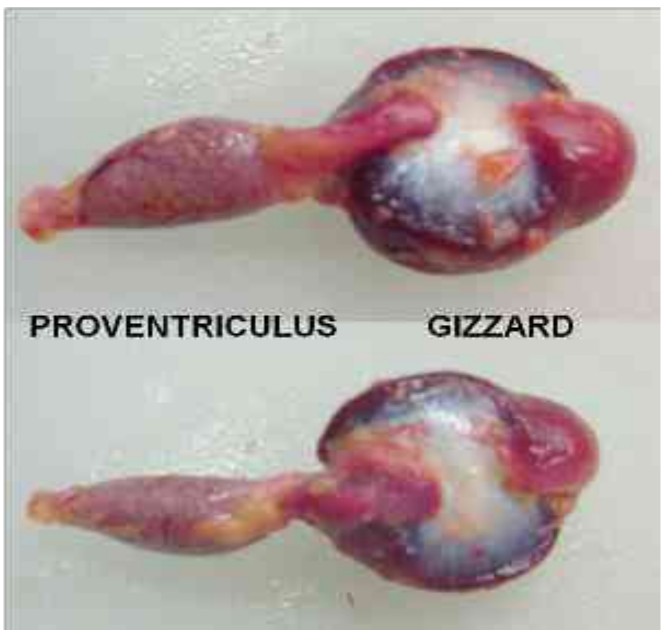
1. Beak/Mouth; As with most birds, a chicken obtains feed by using its beak. Food picked up by the beak enters the mouth. Chickens do not have teeth, so they cannot chew their food. However, the mouth contains glands that secrete saliva, which wets the feed to make it easier to swallow. Also, the saliva contains enzymes, such as amylase, that start the digestion process. The chicken uses its tongue to push the feed to the back of the mouth to be swallowed. **2. Esophagus:** The esophagus is a flexible tube that connects the mouth with the rest of the digestive tract. It carries food from the mouth to the crop and from the crop to the proventriculus.

3. Crop: The crop is an out-pocketing of the esophagus and is located just outside the body cavity in the neck region (see Figure 3). Swallowed feed and water are stored in the crop until they are passed to the rest of the digestive tract. When the crop is empty or nearly empty, it sends hunger signals to the brain so that the chicken will eat more



10 (Location of the crop in a female chicken) figure

4.Proventriculus: The esophagus continues past the crop, connecting the crop to the proventriculus. The proventriculus (also known as the true stomach) is the glandular stomach where digestion primarily begins. Hydrochloric acid and digestive enzymes, such as pepsin, are added to the feed here and begin to break it down more significantly than the enzymes secreted by the salivary glands. At this point, however, the food has not yet been ground—this organ is called the proventriculus because its location in the digestive tract is before the ventriculus, where food is ground .



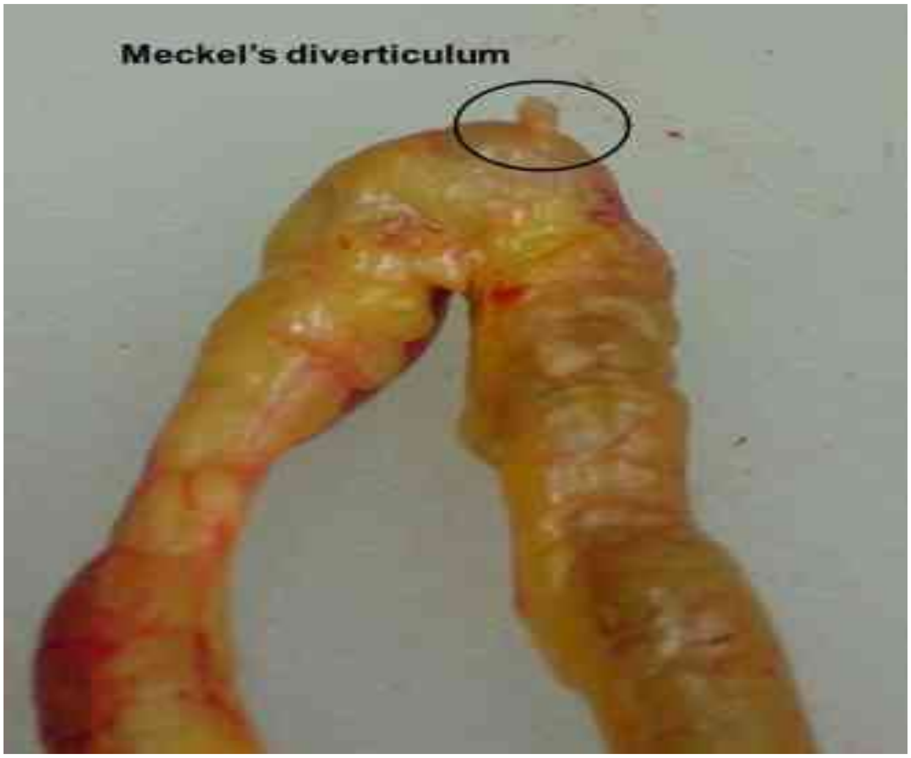
11 (Two views of the proventriculus and gizzard from the digestive tract of a chicken) figure

5. Ventriculus (Gizzard): The ventriculus, or gizzard, is a part of the digestive tract of birds, reptiles, earthworms, and fish. Often referred to as the mechanical stomach, the gizzard is made up of two sets of strong muscles that act as the bird's teeth and has a thick lining that protects those muscles (see Figure 5). Consumed feed and the digestive juices from the salivary glands and proventriculus pass into the gizzard for grinding, mixing, and mashing.

12(Inside of a chicken gizzard, with the internal lining removed) figure

6.Small Intestine***:*** The small intestine is made up of the duodenum (also referred to as the duodenal loop) and the lower small intestine. The remainder of the digestion occurs in the duodenum, and the released nutrients are absorbed mainly in the lower small intestine.The duodenum receives digestive enzymes and bicarbonate (to counter the hydrochloric acid from the proventriculus) from the pancreas and bile from the liver (via the gall bladder). The digestive juices produced by the pancreas are involved primarily in protein digestion. Bile is a detergent that is important in the digestion of lipids and the absorption of fat-soluble vitamins (A, D, E, and K).The lower small intestine is composed of two parts, the jejunum and the ileum.

The Meckel's diverticulum marks the end of the jejunum and the start of the ileum (see Figure 6). The Meckel's diverticulum is formed during a chicken's embryonic stage.



13 (Location of the Meckel's diverticulum in the digestive tract of a chicken) figure

7.Ceca: The ceca (plural form of *cecum*) are two blind pouches located where the small and large intestines join. Some of the water remaining in the digested material is reabsorbed here. Another important function of the ceca is the fermentation of any remaining coarse materials. During this fermentation, the ceca produce several fatty acids as well as the eight B vitamins (thiamine, riboflavin, niacin, pantothenic acid, pyridoxine, biotin, folic acid, and vitamin B12). Because the ceca are located so close to the end of the digestive tract, however, few of the produced nutrients are absorbed and available to the chicken.

8.Large Intestine (Colon): Despite the name, the large intestine is actually shorter than the small intestine. The large intestine is where the last of the water reabsorption occurs. **9.Cloaca:**In the cloaca, the digestive wastes mix with wastes from the urinary system (urates). Chickens usually void fecal material as digestive waste with uric acid crystals on the outer surface—that is, chickens do not urinate. The color and texture of chicken fecal material can indicate the health status of the chicken's digestive tract: the white, pasty material coating chicken fecal material is uric acid, the avian form of urine, and is normal**.**The reproductive tract also exits through this area. When a hen lays an egg, the vagina folds over to allow the egg to leave through the cloaca opening without coming into contact with feces or urine. (Dr. Jacquie Jacob, University of Kentucky)

2.3 Required nutrition in ruminants and poultry:

In Ruminants:

Carbohydrate digestion in ruminant animals:

1. occurs primarily through microbial fermentation in the rumen.
2. Rumen microbes, including bacteria, fungi, and protozoa, degrade dietary carbohydrates to produce energy as ATP for their own growth and protein synthesis.
3. The fermentation process in the rumen produces volatile fatty acids (VFAs), also known as short-chain fatty acids.
4. The major VFAs produced in the rumen are acetic acid (C2), propionic acid (C3), and butyric acid (C4).
5. These VFAs are absorbed through the rumen wall and serve as an energy source for the animal. (Oregon state university ,Animal nutrition)

Fat digestion occurs in the rumen :

1. where bacteria split off fatty acids from glycerol through hydrolysis, leading to

extensive biohydrogenation of unsaturated fatty acids to saturated ones.

2. Most unsaturated fatty acids are hydrogenated to saturated ones (>90%), which are then absorbed through the abomasum and small intestine.

3. The extensive biohydrogenation process reduces potential negative effects of unsaturated fatty acids on rumen fermentation of fiber, explaining why large amounts of free vegetable oils cannot be fed to dairy cows.

4. Lipids leaving the rumen are predominantly free fatty acids and phospholipids, with fatty acids predominantly saturated (80-90%), making them challenging for nonruminants to absorb.

5. Ruminants have developed efficient processes for absorbing saturated fatty acids by forming micelles in the intestine, facilitating their absorption into intestinal cells.

(2007.James K. Drackley, Professor of Animal Sciences)

Proteins:

1. Dietary proteins are broken down into peptides and amino acids by microbial enzymes in the rumen.

2. Microbial proteins produced in the rumen are utilized by the animal as a source of amino acids for growth and metabolism.

3. Some protein may escape microbial degradation and reach the abomasum, where it is further digested by gastric enzymes.

4. Proteins serve various functions in living cells, including enzymatic activity, nutrient and storage roles, transportation of molecules, providing structural support, acting as regulatory molecules (such as hormones), and participating in defense mechanisms (like antibodies).

5. Proteins are derived from diverse sources, including cereals like maize, wheat, and rice (prolamines and glutelins), and legumes (albumins and globulins).

(Barrett & Elmore, 1998)

Vitamins and minerals:

Vitamins and minerals are absorbed along the length of the small intestine, primarily in the jejunum and ileum.

1. Minerals and vitamins constitute a small proportion of daily dry matter intake in ruminants diets
2. Despite their small quantity, minerals and vitamins play crucial roles in beef cattle nutrition, essential for functions like bone development, immune function, muscle contractions, and nervous system function.

In Poultry:

Proteins: (amino acids)

Broken down in the proventriculus Absorbed in the small intestine

• Can be used for energy

• Broken down into amino acids that are used to build and repair tissue (e.g., muscle tissue)

Examples: (Soybean meal or cottonseed meal, Soybean Meal, Cottonseed Meal)

Carbohydrates: (sugars)

• A Carbohydrate is a complex sugar molecule Broken down in the pancreas

• Carbohydrates are turned into glucose

Absorbed by the bloodstream and used for energy

Examples of Carbohydrates: (bread, pasta, or grains)

Fats: (lipids)

Are not water soluble

Bile produced, by the liver, specifically break down fats

• Fats are turned into fatty acids and glycerol which are absorbed and used as an energy source and energy reserve Examples: (Peanut oil or butter, Peanut Oil, Butter) (Poultry Skillathon,2018)

2.4 Ontogeny of digestive system capacity in avian:

1. Dietary Changes in Bird Development: Birds undergo significant dietary changes during development, transitioning from a lipid and protein-rich diet (yolk and albumen) in the embryo to a carbohydrate-rich diet post-hatch, particularly in granivorous species.

2. Developmental Differences between Precocial and Altricial Birds: There are temporal differences in the development and maturation of digestive systems between precocial and altricial birds, with altricial birds relying more on parental care and assistance in digestion.

3. Allometric Growth of Digestive Tract: The embryonic digestive tract grows at a faster rate than the rest of the body, allowing for functional development by hatching, which facilitates efficient digestion and rapid postnatal growth.

4. Role of Gizzard and Parental Assistance: The gizzard is relatively small and weak after hatching, gradually increasing in strength as the chick consumes food. Parents of altricial chicks may aid in digestion by softening food with saliva before regurgitation.

5. Colonization of Digestive Tract by Microflora: Birds hatch with a sterile digestive tract, but colonization occurs rapidly through parental feeding and ingestion of microflora from the nest environment. This colonization process continues until a "normal" flora develops.

These points highlight key aspects of the ontogeny of digestive capacity in birds, including dietary transitions, developmental differences, anatomical changes, and microbial colonization.(1999,W.B.Saunders Company)

2.5 Ontogeny of digestive system capacity in ruminants:

1. Neonatal Period: Ruminants are born with a relatively undeveloped digestive system and rely on colostrum for passive immunity and essential nutrients. During

this period, the digestive system undergoes rapid growth and adaptation.

- Source: Van Soest, P. J. (1994). Nutritional Ecology of the Ruminant (2nd ed.). Cornell University Press.

2. Rumen Development: The rumen, a fermentation chamber, undergoes significant development postnatally. Microbial colonization of the rumen begins shortly after birth and plays a crucial role in fermentation and nutrient processing.

- Source: Hungate, R. E. (1966). The Rumen and Its Microbes. Academic Press.

3. Transition to Solid Feed: As ruminants transition from liquid to solid feed, the rumen adapts to handle roughage and concentrates. Changes in microbial populations and enzyme activity occur to efficiently digest and ferment complex carbohydrates.

- Source: Baldwin, R. L., & Allison, M. J. (1983). Rumen metabolism. Journal of Animal Science, 57(Suppl. 2), 461–477.

4. Weaning and Dietary Adaptation: Weaning marks a significant milestone as ruminants shift to a diet consisting primarily of solid feed and forage. This transition stimulates further development and maturation of the rumen and other digestive organs.

- Source: Warner, A. C. I. (1975). The Digestive System in Mammals: Food, Form, and Function. Academic Press.

5. Maturation of Digestive Organs: Throughout early life, digestive organs such as the stomach, small intestine, and large intestine continue to mature and increase in size and capacity.

- Source: Forbes, J. M. (2007). Voluntary Food Intake and Diet Selection in Farm Animals. CABI Publishing.

2.6 Fermentation in ruminants and poultry:

Rumen fermentation: is a process that converts ingested feed into energy sources for the host. specialized stomach compartment the rumen, where microbial fermentation takes place.

Microbial fermentation in ruminants is a complex process involving various microorganisms that break down feed components into digestible nutrients. Bacteria, protozoa, and fungi work symbiotically in the anaerobic environment of the rumen to degrade substrates such as cellulose, starch, pectin, and proteins (Ozutsumi et al., 2005; Pitta et al., 2010

1. Ruminal Bacteria:

- Cellulose-degrading bacteria such as Fibrobacter succinogenes and Ruminococcus flavefaciens play a vital role in digesting cellulose from plant-based feeds (Russell et al, 2009).

- Starch-degrading bacteria like Streptococcus bovis and Bacteroides ruminicola are essential for breaking down starch in the diet, but their overgrowth can lead to metabolic disorders like acidosis (Gressley et al, 2011).

2. Lactate-degrading Bacteria:

- Megasphaera elsdenii metabolizes lactic acid, helping to maintain proper ruminal pH, especially in diets high in grains (Counotte et al, 1981).

3. Pectin-degrading Bacteria:

- Bacteria such as Butyrivibrio fibrisolvens and Prevotella ruminicola are important for fermenting pectin, a significant component of forage carbohydrates (Dehority, 1969).

4. Proteolytic Bacteria:

- Bacteroides amylophilus and Butyrivibrio fibrisolvens are key players in degrading proteins and peptides in the rumen (Cotta and Hespell, 1986).

5. Ruminal Archaea or Methanogens:

- Methanogens like Methanobrevibacter ruminantium produce methane as a byproduct of fermentation, contributing to greenhouse gas emissions (van Zijderveld et al, 2011).

6. Protozoa:

- Holotrichs and Entodiniomorphida protozoa play roles in fermenting sugars and cellulose, with some species aiding in reducing the risk of acidosis by assimilating soluble sugars (Firkins et al, 2007).

7. Ruminal Fungi:

- Cellulolytic fungi such as Neocallimastix frontalis and Piromyces joyonii assist in breaking down plant cell walls, particularly lignified substrates (Bernalier et al, 1992).

These microorganisms work together in a symbiotic relationship to efficiently digest the complex carbohydrates and proteins present in the ruman

Poultry fermentation

Microbial fermentation in poultry refers to the process by which intestinal bacteria break down indigestible dietary carbohydrates, such as polysaccharides, oligosaccharides, and disaccharides, into their compositional sugars. These sugars are then fermented by intestinal bacteria, primarily in the cecum of birds, yielding short-chain fatty acids (SCFAs) such as acetate, propionate, and butyrate. This fermentation process primarily takes place in the cecum, which is densely populated with bacteria. The fermentation of dietary carbohydrates by gut bacteria in avian species serves several important functions:

1. Energy and carbon source: SCFAs produced through fermentation can be utilized by the host as an energy and carbon source.

2. Regulation of intestinal physiology: SCFAs, especially butyrate, play a role in regulating intestinal blood flow, stimulating enterocyte (intestinal cell) growth and proliferation, regulating mucin production, and affecting intestinal immune responses.

3. Nitrogen metabolism: Cecal bacteria in birds can catabolize uric acid to ammonia, which can be absorbed by the host and used to synthesize certain amino acids such as

glutamine. Some dietary nitrogen is also incorporated into bacterial cellular proteins, although the majority of these proteins are lost to the host through fecal excretion.

4. Vitamin synthesis: Gut bacteria in poultry can serve as a source of vitamins, especially B vitamins, for the host. However, most of the synthesized vitamins are excreted with feces, although coprophagic birds may benefit from bacterial vitamin synthesis.

5. Nutrient exchange: Birds can also provide nutrients to intestinal bacteria, such as mucins produced by goblet cells in the gut, which serve as sources of carbon, nitrogen, and energy for certain commensal and pathogenic bacteria.

Overall, microbial fermentation in avian plays a crucial role in nutrient metabolism, intestinal health, and host-microbe interactions. It contributes to the efficient utilization of dietary nutrients and the maintenance of gut homeostasis in birds.

2.7 The role of digestive enzymes in ruminants and poultry:

2.7.1 digestive enzymes in ruminants:

1. Amylase: Pancreatic α-amylase responds to changes in carbohydrate intake, with increased intake leading to higher concentrations and secretion of amylase. However, the exact mechanism of this response is not fully understood. Dietary carbohydrate sources, protein quality, glucose, and insulin play roles in regulating pancreatic α-amylase. The response differs between non-ruminants and ruminants, with evidence suggesting that glucose and insulin are involved in the adaptive response in non-ruminants, but the regulatory signals may differ in ruminants.

2. Disaccharidases: Carbohydrase activity in the small intestine, including sucrase, maltase, and lactase, is inducible by diet in non-ruminants. Ruminants also show adaptation of intestinal disaccharidases, although the magnitude of response may be smaller compared to non-ruminants. Studies suggest that dietary adaptation of intestinal disaccharidases occurs in ruminants, but more research is needed to

understand the exact mechanisms.

3. Proteases: Pancreatic trypsin and chymotrypsin respond to dietary protein intake in non-ruminants, with high protein diets increasing their concentrations and synthesis rates. However, adaptation of pancreatic proteases responds only to luminal protein, not intravenous or intraluminal amino acids. Limited data are available for ruminants, but young calves seem more sensitive to nutritional modification of digestive enzymes compared to older ruminants.

4. Peptidases: Peptidases in the small intestine are sensitive to nutritional influences in non-ruminants, but information for dietary influences in ruminants is lacking. Brush border peptidase activity decreases with feed deprivation, while cytosolic peptidase activity increases, potentially to supply amino acids for gluconeogenesis. However, more research is needed in ruminants to understand the dietary influences on peptidases.

5. Lipase: Pancreatic lipase responds to dietary triglyceride intake in non-ruminants, increasing with higher dietary fat levels. Limited data are available for ruminants, but both cattle and sheep secrete pancreatic lipase similar to non-ruminants. However, the regulatory signals for pancreatic lipase may differ in ruminants compared to non-ruminants, and more research is needed to understand these differences.

Overall, while there is considerable understanding of digestive enzyme regulation in non-ruminants, there is a need for more research to fully elucidate the mechanisms in ruminants. Additional studies could focus on the specific dietary factors and regulatory signals influencing digestive enzyme activity in ruminants.

1993), J Dairy)

2.7.2 Digestive enzymes in avian

1. Amylase: This enzyme breaks down starches (complex carbohydrates) into smaller sugar molecules like maltose and glucose. It plays a crucial role in carbohydrate

digestion.

2. Lipases: Lipases break down fats (lipids) into fatty acids and glycerol, facilitating fat digestion and absorption.

3. Trypsin and Chymotrypsin: These are protease enzymes that break down proteins into smaller peptides and amino acids. They are secreted in inactive forms (trypsinogen and chymotrypsinogen) and are activated within the small intestine.

4. Carboxy-peptidases A, B, and C: These enzymes also participate in protein digestion, breaking down peptides into smaller peptides and amino acids.

5. Deoxyribonucleases and Ribonucleases: These enzymes break down DNA and RNA, respectively, into nucleotides, which can then be further broken down into their component molecules for absorption.

6. Elastases: Elastases specifically target elastin, a protein found in connective tissue. They help in the digestion of elastin-containing tissues.

These enzymes collectively work to break down complex macromolecules present in food (such as proteins, fats, carbohydrates, and nucleic acids) into smaller, absorbable molecules that can be utilized by the body for energy, growth, and repair.

(1999,Seminars in avian and exotic oed medicine)

3.Conclusion and Recommendations:

3.1Conclusion:

1. Digestive Anatomy and Function: Ruminants possess a complex digestive system with multiple compartments optimized for the breakdown and absorption of fibrous plant material, while poultry have a streamlined digestive tract adapted for efficient nutrient extraction from seeds and grains.

2. Nutritional Adaptations: Ruminants rely on microbial fermentation in the rumen to digest cellulose and hemicellulose, while poultry ferment indigestible carbohydrates in the ceca. Both groups have specific dietary requirements for carbohydrates, proteins, fats, vitamins, and minerals to support growth, reproduction, and overall health.

3. Developmental Differences: Birds undergo significant dietary transitions and developmental changes in their digestive systems from embryo to post-hatch stages, while ruminants experience rapid growth and adaptation of their digestive organs during the neonatal period and beyond.

4. Role of Microbes: Microbial populations play a crucial role in the fermentation processes of both ruminants and poultry, contributing to the breakdown of complex carbohydrates and proteins into absorbable nutrients.

5. Enzymatic Activity: Digestive enzymes in both ruminants and poultry are essential for breaking down macromolecules into smaller, absorbable components. These enzymes respond to changes in diet composition and play a vital role in nutrient digestion and absorption.

6. Practical Implications: Understanding the ontogeny of digestive capacity and the role of fermentation and digestive enzymes is vital for developing optimal feeding strategies, promoting animal health, and maximizing productivity in both ruminant and poultry production systems.

In conclusion, the research underscores the importance of comprehensively understanding the digestive physiology of ruminants and poultry to ensure efficient nutrient utilization, animal welfare, and sustainable production practices in the livestock industry. Further research in these areas will continue to advance our knowledge and inform evidence-based management strategies for optimal animal nutrition and performance.

3.2..Recommendations:

1. Comprehensive Understanding of Digestive Anatomy: Acquire a thorough understanding of the intricate anatomy and physiology of both ruminants and poultry digestive systems, including the specific functions of each compartment. This knowledge is fundamental for designing effective feeding programs and addressing any digestive health issues.

2. Tailored Nutrition Programs: Customize feeding programs to meet the unique dietary needs of ruminants and poultry, considering factors such as carbohydrate fermentation, fat digestion, protein breakdown, and micronutrient requirements. Ensure a well-balanced diet to support growth, reproduction, and overall health.

3. Promotion of Efficient Digestion: Implement feeding strategies aimed at promoting efficient digestion and nutrient absorption. Select feed ingredients that are easily digestible and optimize conditions for microbial fermentation in ruminants and fermentation in poultry ceca.

4. Regular Monitoring for Health and Performance: Monitor the health and performance of livestock regularly to detect any signs of digestive disorders or nutrient deficiencies. Adjust feeding practices and nutritional interventions as needed to maintain optimal health and productivity.

5. Continuous Learning and Innovation: Stay updated on the latest research and innovations in ruminant and poultry nutrition. Seek opportunities to improve feeding strategies, enhance nutrient utilization, and advance animal welfare and productivity in your operations.

By following these recommendations and maintaining a deep understanding of the digestive physiology and nutritional requirements of ruminants and poultry, you can optimize feeding programs, promote animal health, and maximize productivity in your livestock operations.

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