1967

A Short History of Early Digestion Trials

D. Dale Gillette

Iowa State University

Follow this and additional works at: https://lib.dr.iastate.edu/iowastate_veterinarian

Part of the Veterinary Physiology Commons

Recommended Citation

Gillette, D. Dale (1967) "A Short History of Early Digestion Trials," Iowa State University Veterinarian: Vol. 30 : Iss. 1 , Article 3.
Available at: https://lib.dr.iastate.edu/iowastate_veterinarian/vol30/iss1/3

This Article is brought to you for free and open access by the Journals at Iowa State University Digital Repository. It has been accepted for inclusion in Iowa State University Veterinarian by an authorized editor of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.
A Short History of Early Digestion Trials

by D. Dale Gillette, D.V.M., Ph.D.

Although Hippocrates (C.400 B.C.) ascribed certain qualities to food and founded a dietetics based on personal observations and the accumulated knowledge of the era (8) and although Erasistratus of Julius at Alexandria (C.300 B.C.), "Father of Physiology," traced hunger to an empty stomach; little was done in actual trials to determine the digestible nutrient value of foods. The first trials apparently were made by Francesco Redi (1626-1698) as an experimental investigation of the grinding power of the gizzard of household fowl. (17)

In this dawn of nutrition Albrecht Von Haller (1708-1777), the most prominent physiologist of the eighteenth century, writes: "Receptum est in hominum opinione quod ossa animalibus subigantur; cum Helmontianis olim sensit Boerhaavius; (5) ut vero certior esset curam adhibuit, ut observaret, quid cibis fieret in ventriculis animalium valde cibos coquentium & experimento cognovit non subigi. Dedit cani devoranda intestines animalium, famelicus affatim deglutit; subegit minime & per extremum intestinum pendula misere post se traxit. Dedit famelico cani ossa butyro inuncta, reddidit furfura, neque quidquam dissolvit nisi quod in aqua dissolvi potest. Dedit carnes, reddidit fibras curnis exsuxcas. Dedit ligamenta, ea post tridium nihil mutata egessit." This was

Dr. Gillette is an Associate Professor in the Department of Veterinary Physiology and Pharmacology, Iowa State University.

Some of this material is found in Fulton's writings on the history of physiology (4).

"Established in human opinion is the digestion of bones as declared by Helmont and Boerhaave; there I contend it might be put to treatment; so it was observed how food fired in the belly of animals, food well cooked and from experiments known not to be broken down. A hungry dog was given animal intestines, he ate sufficiently, digested minimally and from his anus a wretched hanging thing protruded. A hungry dog was given bones smeared with butter; he voided a bran-like substance only a part of which could be dissolved in water. Meat was given, given back was stringly, flesh juice. Ligament was given and after eating nothing was discharged."
gallinaceous birds and retrieved them with the barley entire. Thus he concluded that in those birds food was broken down not by a solvent but by muscular action. He supposed the gizzard stones necessary to digestion.

By employing similar tubes filled with grass and forced into sheep, Reaumer found the grass undigested when he killed the sheep or if the sheep were allowed to void the tube. Thus he claimed that digestion in sheep could not be effected by a solvent.

Working with a large kite, a scavenger bird, because of the periodical vomiting of the bird he discovered several things. Most important he noticed flesh was dissolved according to the length of time in the body and ascribed digestion to a dissolving process by the gastric juice. He also disclaimed Dr. George Cheyne (1671–1743) of London and Bath, who claimed that crows cannot digest flesh of their own species, but vomit it up. (3)

In 1760 a certain Mr. Gosse who had developed the ability to vomit at will merely by swallowing air, started observations on digestion.* He would eat essentially the same supper upon “diverse occasions” and after various lengths of time would vomit it up and examine the results:

⅓ hour: not much change, foods retained taste, milk curdled
1 hour: pulpy, well mixed with gastric juice, no fermentation present, foods retained taste except wine which was much milder.
2 hour: very pulpy and only ⅓ of the food left.

Upon numerous trials he made up what might be the first digestibility lists of food:

I. Substances not digested or such as were not digested in the usual time.

   Animal foods: tendonous parts of flesh, bone, fats, cooked egg white
   Vegetable foods: nuts, seeds, oils, dried grapes, skin of fresh grapes, skin of stone fruits such as cherries and peaches, conserves of oranges and citrons, capsule of apples and pears, cherry stones

II. Substances less indigestible

   Animal foods: pork, black-pudding, egg yolk, egg fritters, fried eggs and bacon
   Vegetable foods: coarse salads, raw vegetables, warm bread, figs, sometimes pastries, onions and leeks (raw or cooked) fried foods were worse.

III. Substances easily digestible

   Animal foods: flesh of young animals and poultry, fresh eggs (uncooked) and milk, fish
   Vegetable foods: leafy green vegetables, asparagus, boiled fruits with sugar, meals of various grains especially without husks, bread, boiled rapes, turnips and potatoes

IV. Substances facilitating digestion

   salt, spices, mustard, capers, wine, cheese (espc. very old cheese), sugar, bitters

V. Substances retarding digestion

   hot water, acids, astringents, oils and employment after a meal.”

In this era Dr. John Pringle (1707–1782), a professor at Edinburgh, and Dr. David Macbride (1726–1778) of Dublin developed a theory that digestion was fermentation. (10,13) They based it upon experiments in which they mixed various foods with water or saliva and kept them at warm temperatures. They observed stages of fermentation of food into a sweet substance. This they correlated with observations in their medical practices of swelling, rarefaction, froth and air bubbles and movement of intestines in people recently dead. They theorized that food, excited by warmth, old residue food, movement, gastric juice, and above all by saliva fermented into a sweet mild nutrient called chyme.

John Hunter (1728–1793), F.R.S. and Surgeon to St. George’s Hospital, observed that the stomach of a man who was accidentally killed when in perfect health and just after a large meal, was dissolved away at the great curvature. He saw this repeated several times. (7)

Edward Stevens of Edinburgh, employed for experimentation “an Hussar, a man of weak understanding who gained a

---

* Certain sources were not available and could not be verified. The author believes they are mentioned by Spallanzani (19).

Iowa State University Veterinarian
miserable livelihood, by swallowing stones for the amusement of the common people, at the imminent hazard of his life.” (20) Dr. Stevens gave this man a two-compartmented silver sphere which was pierced with needle sized holes. Voided in 21 hours the 4½ scruples of beef on one side was reduced to 3 scruples and the 5 scruples of fish on the other was reduced to 3. The residue was softened but had no disagreeable odor. He then made the holes in the sphere much larger and introduced chewed beef. The sphere was voided empty in 38 hours. He also observed that raw potatoes and parsnips were dissolved, but that bone was not. In an attempt to find effects of gastric juice upon living material, he put in live blood sucking leaches and earthworms—all were dissolved.

Unfortunately the Hussar left Edinburgh and Dr. Stevens continued the experiments with dogs and sheep. In dogs he got similar results with ivory spheres—however the spheres themselves were digested away after 3 repeated trials. He found bone and fat to be dissolved away in the dog, but cartilage was not. In sheep he stated flesh was not digested, but that turnips and potatoes were.

Dr. Stevens was most probably the first to conduct digestion trials in vitro. Ripe mutton placed in gastric juice dissolved without putrefying, but the same placed in water gave off a terrible stench. He concluded that digestion is the result of a powerful ferment, which the vital principle keeps from digesting the stomach. (He was familiar with the observations of John Hunter.)

In 1784 Lazaro Spallanzani published the results of significant experiments in digestion. (19) He repeated the trials of Reaumer and obtained the same results. After using crop soaked grain and changing from perforated tubes to a perforated sphere, he reluctantly concluded that the gizzard triturated the food. Using bread and flesh he saw all stages of digestion. He found that complete digestion takes about 5 hours. He correctly ascribed slower digestion of larger hunks to their relatively smaller surface area.

By observing how a fresh mammalian stomach lining became moist again after the surface was wiped dry, he concluded that invisible glands secreted the gastric juice.

He incubated mutton and wheat with gastric juice and with water as a control. He satisfied his critics that digestion and putrefaction were indeed distinct processes. Spallanzani rejected the idea of fermentation being the basis of digestion because he did not find fermentation in animals freshly killed after being fed, but that the food (flesh) had dissolved according to the time it was in the animal. To test Boerhaave’s ideas he fed intestine, tendons, ligaments, and bone to a dog. They were digested—but not completely and quite slowly. Ascribes Boerhaave’s mistake “perceiving some intestine which he had given to a dog hanging out behind he concluded that the animal could not digest such substances.” Spallanzani had a great influence in wiping out fallacies in the areas of his experiments.

During trials with membranous stomached animals (his classification—which included most mammals) and with intermediate stomachs of crows and herons, Spallanzani noticed the round worms had resisted digestion. Attributed it to the acclimation by the worms and to preferential digestion by the stomach. (Whatever that is?)

In ruminants he repeated the work of Reaumer, but used larger tubes, 8” by 4”, and had to contrive what he called a hollow cane to force them down. (Was this the first speculum?) He gave 6 tubes to a sheep, fasted it 27 hours, killed it, and retrieved the tubes—no visible digestion. Upon repeating and letting animal live 37 hours he found the tubes undigested in the fourth stomach. Upon repeating and letting animal live 37 hours he found the tubes undigested in the fourth stomach. After speculating on the effects of rumination he put grass which had been masticated by humans in the tubes and found digestion had occurred. "But as the stomachs of ruminating quadrupeds have no sensible triturating power and the aliment requires trituration, nature has wisely provided for this by causing it to ascend in consequence of a gentle stimulus to vomit, into the cavity of the mouth where by means of rumination it
receives the necessary predisposition to be digested by the gastric fluid.

After Spallanzani's contributions to digestion, trials came more frequently, but not always more correctly. The first American contribution, a thesis on digestion in 1803, was from John R. Young, son of an emigrant Irish physician. He convincingly established the presence of an acid in the living stomach in this thesis, excerpts of which are quoted. "We were therefore, lead at first to suppose, the acid was only present when this viscus was in a morbid state; but experiments proved to us the contrary." "... the following day, I took some meat on an empty stomach, in half an hour afterwards, by irritating my fauces, the meat was thrown up, and with it some gastric fluid: Upon being tested, an acid was very evidently present."

"But does the gastric fluid act upon them before death? The following experiment proved to us clearly it did not . . ."

"Two threads were tied around the forelegs of a live, and common sized spring frog; its whole body, except the head and forelegs was introduced into the stomach of one of the large frogs . . . They were put in a basin containing a little water, where they remained undisturbed for one day and a half. The small frog upon being drawn out, was perfectly alive and its whole body covered with gastric juice, and not the least dissolved in any part."

Delabere Blaine asserted that digestion in herbivores continues long after ingestion.* A. P. Wilson-Philip (1770–1847), an erratic Scottish genius, said that the layer of food next to the stomach wall is digested first. (23) Roget Bridgewater considered blood and a chyme the ultimate products of digestion and upon the basis of a chemical analysis pronounced them identical in composition in the different animals.* Antonio Montegre (1779–1818) considered saliva as the principal agent of digestion. (11)

To point out the darkness still ahead, the following concepts were taken from Principles of Digestion 1841 by Andrew Combe.

---

* Certain sources were not available and could not be verified. The author believes they are mentioned by Spallanzani (19).
is writing of albumens), including gelatine; differ from the oleaginous and saccharine principles, in this respect; that they contain a fourth elementary principle, namely, azote. Such are the three great staminal principals from which all organized bodies are essentially constituted. Moreover, these staminal principals, in all their forms, are capable of readily passing into one another, . . .: "—food must necessarily consist of one or more of the above staminal principals."

"Water may constitute an essential element of a substance—in which case, the water cannot be disunited without destroying the compound; or water may constitute an accidental ingredient."—"carbon, water and similar bodies always enter into combination, not as single molecules, but as one supermolecule."

Prout had great insight, he is known for his speculation that all atomic weights are exact multiples of that of hydrogen or half that of hydrogen. He also discovered the stomach contains hydrochloric acid. (14)

A summary of the facts obtained by William Beaumont’s experiments with the gastric fistula in the side of Alexis St. Martin from 1825 to 1834 is as follows: (2)

1. Digestion of meat in vitro occurs as quickly as in the stomach.
2. Digestion occurred on the surface of the food particles.
3. Heat seemed to be increased during digestion.
4. Contact of food with gastric mucosa stimulated flow of gastric juice.
5. Fasting gastric juice was described as “It was clear and almost transparent; tasted a little saltish and acid, when applied to the tongue, similar to a thin mucilage of gum arabic, slightly acidulated with muriatic acid.”
6. Difference in milk clotted with gastric juice from that treated with acetic acid.
7. Failure of vegetable tissue to disappear as did meat.
8. Cold gastric juice had little activity.
9. “Oil is particularly hard on digestion.”
10. Stomach has characteristic motions.
11. Hydrochloric and acetic acids do not digest foods as does gastric juice. Beaumont said “probably the gastric juice contains some principles inappreciable to the senses.”

After 1840 most of the significant experiments in digestion were carried out by German workers. Amidst the flowering of one of the great Germanic periods in chemistry, physics and physiology, experiment stations were set up at Weende, Halle, Mockern, Proskau, Bonn, Breslau, Vienna, Hohenheim, Munster and Munich—dealing mainly with farm animals. Foods were classified as albuminoids (proteins), fats and carbohydrates (for quite a while, though, carbohydrates were rather neglected). Animals were fed different rations, excreta were collected and analyzed. Pettenkofer constructed an elaborate respiration apparatus in Munich to determine fat and water involved in respiration and perspiration. Mathematics and a new knowledge of chemistry were combined to give calculations of flesh, fat and water gained or lost during feeding trials. Digestibility and composition of many foodstuffs were determined. Control groups were run. The term "Nutritive Ratio" was coined.

This new knowledge plus the establishment of feeding standards were gathered in Landwirtschaftliche Futterungslehre by Prof. Emil V. Wolff, director of the Royal Agriculture College at Hohenheim in 1874. This very important work was translated to English in 1895 and was the basis of Feeds and Feeding first published in 1898 by W. A. Henry, Dean of Agriculture and director of the Agricultural Experiment Station, University of Wisconsin. His book became the world famous Feeds and Feeding by Morrison.

Armsby also reported extensively on these experiments in his classical text on animal nutrition. (1) Highlights of this era (1850–1890) are presented below with certain more comprehensive references (which were not available to the author). Many individual works can be found in the Zeitschrift fur Biologie, founded in 1865 by Voit, Pettenkofer and Buhl.

REFERENCES
EARLY INVESTIGATORS

<table>
<thead>
<tr>
<th>Investigator</th>
<th>Major Place</th>
<th>Pertinent Work</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pettenkofer</td>
<td>Munich, Germany</td>
<td>Respiration apparatus for digestion trials and &quot;respiratory quotient.&quot;</td>
<td>12</td>
</tr>
<tr>
<td>Voit &amp; Bischoff</td>
<td>Munich, Germany</td>
<td>Respiratory apparatus, Fat from fat-free meat. Nitrogen balance studies.</td>
<td>21, 22</td>
</tr>
<tr>
<td>Lawes &amp; Gilbert</td>
<td>Rothamsted, England</td>
<td>Composition of fattening animals. Fat from carbohydrates.</td>
<td>9</td>
</tr>
<tr>
<td>Henneberg &amp; Strohan</td>
<td>Weende</td>
<td>The more food the more converted to flesh.</td>
<td>6</td>
</tr>
<tr>
<td>Zuntly &amp; Hagemann</td>
<td>Berlin</td>
<td>31.5% efficiency from food to work.</td>
<td>26</td>
</tr>
<tr>
<td>Rubner</td>
<td>Munich</td>
<td>Caloric values of food stuffs. Replacement of nutrients for heat production.</td>
<td>18</td>
</tr>
<tr>
<td>Wolff</td>
<td>Hohenheim, Germany</td>
<td>Variable digestibility of fodder.</td>
<td>24</td>
</tr>
</tbody>
</table>

REFERENCES

14. Prout, William, On the nature of the acid and saline matters usually existing in the stomachs of animals, Phil. Trans. 114, 1824.
17. Redi, Francesco, Osservazioni Intorno agli Animali Vivienc. Firenze, Italy, 1848.

A Purse-string Suture Technique for Retention of Coxofemoral Luxations

(Continued from page 6)

REFERENCES

6. Hagemann, H., Fixation After Reduction of Luxation of the Coxofemoral Joint in Dogs, The Iowa State University Veterinarian