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RECENT FINDINGS AND FUTURE PERSPECTIVES OF RABBIT'S DIGESTIVE PHYSIOLOGY

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Introduction

The rabbit is one of the most common laboratory animals, consequently there is an enormous number of publications concerning its physiology. As an example, the excellent review of Nordio-Baldissera (1980) can be shown, which dealt with reproductive and digestive physiology, containing 60 pages and based on 426 articles. Considering the limited presentation time, the invited lectures of the 3rd World Rabbit Congress confined their paper to one special topic ; namely Gallouin (1984) spoke about the cecotrophy related questions. The present review deals mainly with the new findings of the rabbit's digestive physiology, without giving full details of the previous, fundamental data. For more detailed, methodical up-to-date description of the theme see Cheeke (1987).

Feed intake regulation

The rabbit's feed intake depends basically on two factors, i.e. on the feeling of hunger and appetite. The first is the result of some objective physiological functions: the decrease of the blood glucose, amino acid, lactic and volatile fatty acid level, the desiccation of buccal and pharyngeal mucous membranes and the contractions of the empty stomach (LeBars, 1976; Hörnicke, 1978). On the contrary, the appetite is a subjective, acquired phenomenon, which contains not only the habit of the feeding time, but also the preference of the animal. The latter is especially important at the rabbit, because the individual differences are great (Cheeke, 1974 ; Fekete and Lebas, 1983).

The "feed intake according to the energy" is a characteristic feature of the rabbit. It means that - between certain limits - the daily dry matter intake is determined by the actual energy need of the animal (Lebas, 1975 ; Dehalle, 1981 ; Maertens and De Groote, 1981). This self-regulating capacity is still underdeveloped at the young animals and it can be considered as of full value approx. from the 35th day of life (Fekete and Gippert, 1985).

The regulating mechanism can be disturbed by some antinutritive substances of

creased the voluntary feed intake by 60 and 70 % respectively (Fekete et al., 1988a). Among the other influencing factors one has to emphasize the environmental temperature : the feed intake decreases above the optimal 15-17 °C (Papp, Kovács and Rafai, 1983).

For the sake of the logical unity the regulation of the cecotrophy should be described here. It depends upon three main factors, i.e. the stimulation of rectal mechanoreceptors, the perception of the specific odour of the soft feces and the inner motive determined by the blood level of metabolites and hormones. For the later we have only indirect evidences. Namely, in case of an energy deficiency of the organism the rabbit consumes the total quantity of the produced cecotroph (Kalugin, 1980). During ad libitum feeding the dry matter intake depends on the protein requirement of the animal, or more precisely on the protein and fiber level of its ration (Fekete and Bokori, 1985). It means that the cecotrophy is higher if the feed mixture contains protein and/or more fiber. It's confirmed indirectly by De Blas et al. (1986) who observed the diminution of the stomachal cecotroph content on a low-fiber diet, presumably owing to a reduced intake. These findings are close to those of Roger and Leung (1973) who found at the cat a depression of feed intake and avoidance of diet containing an excess of amino acids. The most commonly accepted idea concerning the metabolites mediating the amino acid effect are the amino acids themself through some receptor system in the gastrointestinal tract, liver and/or the brain. The production of the soft feces practically is independent of the amount and composition of the ration (Laplace, 1978). It is the composition of the cecotroph that varies according to the diet (Proto, 1968).

The time of the feed intake is a regulating factor of drinking, kinetic activity, excretion of urine and feces (Jilge, 1986).

Digestion and absorption. Species characteristics.

The relative volume of the different sections of the digestive tract is different from the other domestic animals. From the functional point of view it is worth mentioning that it is the rabbit which has the greatest stomach and cecum (35.5 vs 42.8 % of the total wet content respectively) among the monogastrics (Lebas and Laplace, 1972). There is a significant difference between the static and the so-called functional volume, the later estimated at 0.67 kPa overpressure : 53 vs 297 ml/$W^{0.75}$ (Herd and Harrop, 1978). The pH-value varies in the different parts of the digestive tract : on an average, it is 2.0-2.2 in the stomach, 6.1 in the duodenum, 7.3 in the jejunum, 7.2 in the ileum, 5.7-6.1 in the cecum and 6.1-6.5 in the colon (Matthes, 1981 ; Morisse et al., 1985). The dry matter content of the cecal material is 20-25 %. The acidic pH of the cecum content is due to a microbial fermentation which produces VFAs from the fiber (Marty and Raynaud, 1966 ; Vernay and Raynaud, 1975).

The total germ count in the cecum is 10^{9}/gram content, in the colon and rectum 10^{8}, in the jejunum 10^{4-5}/gram. It is the Bacteroides genus which occurs in the greatest proportion (10^{2-9}/g) ; owing to the feeding Lactobacilli, Clostridia and Coli bacteria (10^{1-3}/g) can appear (Weber et al., 1974; Matthes, 1981). Forsythe and Parker (1985a) reported about a rabbit-specific saccharomyces, Cyniclomyces guttulatulus (10^{6}/g) in the cecum. In the same digestive section of the healthy rabbit Lelkes and Chang (1987) found protozoa in a concentration of 10^{6}/ml content.

Digestion and absorption of feed's nutrients

There are few data concerning the characteristics of the rabbit's saliva secretion and composition. It is widely accepted that, as at the other mammals, saliva is formed by a two-stage process in which an isotonic primary fluid with constant, plasma--like electrolyte composition is first formed by the secretory endpieces and then modified in the gland excurrent duct system by reabsorption of sodium and chloride and secretion of potassium and bicarbonate (Young and Van Lennep, 1979). Case et al.

(1981) studied the role of extracellular anions in both phases. Neither of the major extracellular anions (Cl^- or HCO_3^-) is essential for primary fluid secretion, provided that extracellular pH is maintained at 7.4. With respect to ductal modification of the primary saliva, HCO_3^- omission inhibits ductal Na^+ absorption (i.e. salivary sodium concentration will rise).

The degradation of the proteins begins in the stomach under the influence of pepsin-hydrochloric acid complex, which is capable of hydrolysing peptide bonds of most protein, mucin being one important exception (Tennant and Hornbuckle, 1980). The microbial protein of the cecotroph can be digested only after the pre-treatment of a specific bacteriolytic factor, presumably equal to the colonic lysozyme which is incorporated in the soft feces and by means of cecotrophy is transfered to the stomach (Villard and Raynaud, 1968 ; Camara and Prieur, 1984). The digestion of proteins continues in the small intestine owing to the activity of pancreatic trypsin, chymotrypsin, carboxypeptidases A and B. The intestinal mucosa contains a wide range of aminopeptidases which complete the process of protein digestion. Amino acids enter the rabbit jejunal brush burder membrane vesicle via three major routes : nonsaturable simple diffusion, Na-independent carriers and Na-dependent carriers (Stevens et al., 1982). The relative contributions of transport pathways depends on the concentration of amino acid in question. Six fundamental categories of transport systems have been described : simple diffusion, NBB, IMINO, PHE, y^+ and L. Transport across basolateral membranes occurs via passive diffusion and the Na-independent (L) and Na-dependent (A,ASC) carriers, found universally in nonepithelial membranes (Stevens et al., 1984). - The residue of feeding protein and digestive enzymes fall in the cecum, where it will be utilized by the microorganisms.

The digestion and absorption of lipids goes on similarly to the other monogastrics by means of pancreatic lipase, sterol ester hydrolase, phospholipase A, bile salts and a colipase (Carey et al., 1983). The most important bile acid of the rabbit is the glycochenodeoxycholic acid. The ursodeoxycholic and lythocholic acids occur in smaller quantities too. The hourly average bile production varies between 3.7-9.2 ml, the total acid concentration (mg/100 ml bile) ranges from 72 to 299. The bile acids are excreted conjugated mainly with glycine, in a smaller proportion with taurine (Gregg and Poley, 1966). On the contrary, Dehbi et al. (1985) found that the deoxycholic and lythocholic acids are dominant and the amount of cholic and cheno-deoxycholic acids is negligible. The production shows a circadian rhythm. The contradiction must derive from the different experimental techniques. Approximately 70 % of the rabbit's bile pigments is biliverdin, because the synthesis of the bilirubin - owing to the low biliverdin reductase activity of the liver - is limited (Munoz et al., 1986).

The ready available carbohydrates (sugars, starch) can be totally digested and their absorped end products are the glucose, fructose and galactose. It is worth mentioning that the up-to-date model of transepithelial glucose transport is based on experiments using rabbit's jejunal brush-border and rat basolateral membranes. It was stated that glucose crosses the intestinal brush-burder via one diffusive and two saturable systems (Kaunitz and Wright, 1983). The independent glucose carrier of enterocyte basolateral membrane resembles the facilitated glucose carrier of others membranes. - The hydrolysis of fiber components (pectin, hemicellulose, cellulose) is accomplished by the intestinal bacteria, mostly those of the cecum. The end products of that fermentation are short-chain fatty acids. The proportion of the VFAs in the digestive tract reflects this process : small intestine (total) - 4.8, ileum - 11.1, cecum - 15.4, colon - 11.7 meq/100 gram content (Marty et al., 1973a,b) After starvation the VFA-concentration (especially that of the butyric acid) falls.

The produced VFAs (formic, acetic, propionic, butyric) and the others organic acids, remaining from the feed (malonic, fumaric, succin acid) are actively absorbed through the cecal and colonic wall in the blood. The intestinal wall utilizes a part of these acids (mainly the butyrate) as a source of energy, so the end product of this process, the lactic acid will get into the blood too (Beauville, Raynaud and Vernay, 1974). The proportion of the three main short-chain fatty acids in the cecum is 10 : 1 : 1.5-3, acetic, propionic and butyric acid, respectively (Morisse et al., 1985).

The heat and chemical treatment influences the starch digestibility. The glucose and insulin concentration of blood in rabbit, fed with crude starch does not increase. The heat treatment (100 ^{o}C) enhances the hydrolysis. The quickest hydrolysis and absorption can be obtained by feeding of acetylated distarch adipate (Lee et al., 1985).

Sorption of electrolytes and VFAs in the gut

The duodenal mucosa possesses a considerable capacity for bicarbonate secretion. The absorption of HCO_3^- by the jejunum is an active, metabolically driven process. The rabbit ileum has a considerable capacity for alcalization (bicarbonate secretion) of chyme. There is an interrelationship between bicarbonate secretion and NaCl absorption (Hopfer and Liedtke, 1987). The Na and Cl absorption in the ileum are linked and can be explained by Na--H and Cl--HCO_3 exchanges (Nellans et al., 1974). - During the excretion of the hard feces the chloride will be actively absorped from the proximal colon and secreted in the distal colon. Its absorption from the cecum is passive, i.e. the chloride concentration of the cecal content has to exceed that of the blood plasma (95 meq/l). There is no K movement in any direction in the cecum (Leng, 1978). The cecal appendix secretes an alcaline fluid of high bicarbonate concentration (William et al., 1961). From the cecum there is a rather passive absorption of bicarbonate, the threshold is 19 meq/l. The transport of the chloride and bicarbonate is in connection. The proximal colon actively absorbes water, sodium and chloride, and secretes bicarbonate and potassium, whereas the distal colon absorbes sodium and water and secretes potassium and chloride (Clauss, 1985). The bicarbonate secretion of the colon moderates the pH fall owing to the arising VFAs level (Garcia et al., 1982 ; Vernay et al., 1984 ; Vernay, 1986).

The intracellular Ca^{2+} (with the calmodulin) is involved in regulation of NaCl absorption in rabbit ileum and K secretion in descending colon. The majority of the effect of Ca^{2+} on intestinal transport is mediated by initiation of arachidonic acid metabolism (PGE_2). Increase in intestinal cAMP also alters active Na, Cl and K transport. Agents that increase intestinal cAMP content (e.g. bacterial toxins, bile salts etc.) will inhibit absorption of sodium and chloride and increase K secretion (Donowitz and Welsh, 1986).

Digestive processes in the cecum

The concentration of the bacterial flora in the cecum is 10^{9-11}/gram, with the predominance of the strict anaerob Bacteroides . The main N-sources of the bacteria is the NH_3, produced by their dezaminase and urease activity. The cellulolytic activity is low, so the energy, required for the assimilation of the ammonia, will be gained by means of the degradation of sugars, pectin and xilase. In case of an incomplete protein supply the blood urea will be excreted in the cecum. A certain amount of urea derives from the feed (Knutson et al., 1977). The biuret can be a more efficient N-source than urea (Proto and Gioffre, 1986). The urea will be hydrolysed mainly by bacteria, adhered to the mucous membrane : *Clostridium coccoides*, *Cl. innocuum*, *Peptostreptococcus productus*, *P. micrus*, *Peptococcus magnus*, *Fusobacterium russii* (Forsythe and Parker, 1985a).

In function of the protein level of the feed and the NH_3-concentration of the cecal content the produced ammonia will be built in into the bacteria and will be utilized by the cecotrophy (Robinson et al., 1986). The described utilization of the urea is hindered by feeding of antimicrobial substances (Houpt, 1963). Besides the protein concentration of the feed mixtures, required for the production, the NH_3--assimilating capacity of the cecal flora is trifling, so the supplementation of the rabbit's feed with urea did not result in practical benefit. Namely the average ammonia concentration of the cecum is 5 mmol/l, the effective NH_3-assimilation, on the contrary, occurs at about 1 mmol/l (Forsythe and Parker, 1985b). It is worth mentioning that a certain proportion of the ammonia, produced on the mucous membrane, gets again in the blood.

Cecotrophy

Taxonomically distant mammals (some rodent species, beaver, herbivorous monkeys etc.) developed a particular mechanism allowing the separate excretion of the, rich in nutrients cecal content and the, poor in valuable material normal, hard feces. The reingestion of cecal content (cecotroph) makes possible the better utilization of the nutrients. The cecotroph will be swallowed without chewing. The typical composition of the two types of feces is the following : dry matter 52.7 vs 38.6, crude protein 15.4 vs 34.0, ether extract 3.0 vs 5.3, crude fiber 30.0 vs 17.8, ash 13.7 vs 15.2, N-free extractives 37.9 vs 27.7 %, gross energy 18.2 vs 19.0 MJ, hard feces and cecotroph respectively (Fekete and Bokori, 1985).

The cecotroph and the hard feces - in different time - will be produced in the proximal colon. During the production of the hard feces a separating mechanism, by the contractions of the colonic haustrae, removes the fluid and small particles in the cecum. The process is helped by the active water secretion of the colon (Ehrlich et al., 1983). The fusus coli is supposed to be the pacemaker of the contractions (Ruckebusch and Fioramonti, 1976). The described separating mechanism does not act during the excretion of the cecotroph, which is fundamentally a cecal content, enclosed by the colonic cells produced mucin (Bonnafous and Raynaud, 1967 ; Björnhag, 1972 ; Gallouin and Demaux, 1980). The mucilaginous membrane inhibits the diffusion of ions and absorption of electrolytes.

During the formation of hard feces the cecal content will thoroughly be transformed in the colon. The wall of the proximal colon produces a lytical factor which dissolves the bacteria, especially those of poor in carbohydrate content (Bonnafous and Raynaud, 1978). The distal colon produces, mainly in the soft feces phase, a species-specific lysosim, which will get in the stomach with the cecotroph and there it has a bacteriolytical role (Camara and Prieur, 1984).

The sodium, water and chloride absorption of some part of the proximal, and the total distal colon increases during the hard feces phase (Hörnicke et al., 1984). It is the aldosterone secretion which is responsible for the enhancement of these transports (Vernay, 1985), but the Na^+, Cl^-, HCO_3^- and water absorption in the cecum, as well as the Cl^- secretion in the distal colon are independent of the blood glucocorticoid level (Schäfer, 1985).

Clauss and Hörnicke (1979) kept rabbits in regulated (12 dark -- 12 light hours) light circumstances. Cecotrophy fell between 8 and 12 hours. The aldosterone concentration of the blood plasma and the electric potential difference showed a diurnal rythm. The Na to K ratio of excretum varied between 0.2-1.2 and reached his maximum in the soft feces phase. The aldosterone concentration of blood is the lowest in the cecotroph phase, consequently the sodium level and the Na to K ratio of the cecotroph will be higher than in the hard feces (Clauss, 1985). After Fekete, Maertens and Tölgyesi (1988) the Na to K ratio of the cecotroph is 0.6, that of the hard feces 0.4. In absolute value the cecotroph contained more from both elements. The ACTH-treatment had also an aldosterone-like effect on the hard feces sodium to potassium ratio, it shifted to 0.3. This phenomenon is close to the result of Dürr and Clauss (1984) who described the stimulation of the Na^+ - permeability of descending colon by dexamethasone or aldosterone.

The role of cecotroph in the stomachal carbohydrate degradation

The starch of feed will be hydrolysed under the action of amylase to the molecules of glucose. Amylase can derive from three sources : feed, saliva and cecotrph bacteria. The third has the most important part, being less sensible to the acidic milieu. The produced glucose diffuses into the cecotroph balls and will be transformed into lactic acid and carbon dioxid (Griffith and Davies, 1963). The lactic acid rediffuses in the lumen ; its absorption begins in the stomach, but is completed only in the small intestine (Hörnicke and Mackiewicz, 1976). The mucous membrane, surrounding the cecotroph pellets, plays an important role : it protects the bacteria from the influence of gastric juices (Hörnicke, 1986). In my opinion, the importance of the described phenomenon is not the energy supply by the lactic acid, but rather the lightening of the hind gut's carbohydrate overload, the pancreatic amylase production of the rabbit being relatively modest (Catala and Bonnafous, 1979) and the acidifying of the stomachal content and activating of pepsinogen.

Development and maturation of the gastrointestinal tract

The rabbit's digestive tract reaches its adult proportion to the 4th month of life (Lebas and Laplace, 1972). Marked changes occur in villous membrane composition epithelial cell differentiation and transport processes during this period. The maturation of the small intestine functional unit (i.e. the crypt-villus structure) is very important in the digestive processes. The phospholipid and cholesterol concentration and specific fatty acid content of the microvillous membrane of the small intestine change with age (Pang et al., 1983 ; Schwarz et al., 1984). The results, obtained on rats, suggest that there are essential developmental changes in the glycoprotein content and coat of the intestinal mucous, too (Sheard and Walker, 1988). These differences affect membrane fluidity, organization and receptor function.

The mucosal barrier function is also immature in the newborn rabbit : the intestinal antigen intake and endotoxin binding are greater than in adult animals (Udall et al., 1981 ; Bresson et al., 1984). The feed antigens are absorbed more readily into the circulation during the first weeks of life. After Lecce and Broughton (1973) this period lasts to the 23rd day of life. Stepánkova et al. (1983) consider only the first 8 hours as important in this respect.

The described processes are not independent of the feeding. The small intestine of rabbits, fed with doe's colostrum, will be greater, heavier, and contain more DNA than pups fed artificially during the first day after birth (Hall and Widdowson, 1979). These results suggest the presence of specific trophic and/or stimulating effect on the development of gastrointestinal tract. There is some evidence about the potential role of colostral epidermal growth factor (EGF), nerve growth factor (NGF), somatomedin-C, insulin-like growth factor, insulin, corticosteroids, thyroxine, taurin, glutamine and amino sugars (Sheard and Walker, 1988). The gastrointestinal hormones (primarily enteroglucagon, gastrin and motilin), induced by feeding may also modify the whole process. The formation of the normal enteral microflora is a very important factor of the development of ileal villi (Boot et al., 1985).

Development of digestive enzyme activity

The activity of digestive enzymes of suckling period, except lactase, is low in the first two weeks (Deren, 1971). In the third week, parallel with the decrease of lactase activity, the production of saccharase, maltase, trypsin, chymotrypsin and amylase increase (Lebas et al., 1971 ; Henschel, 1973 ; Alus and Edwards, 1976). As to the proteolytic enzymes, that is a so-called two-step development of enzyme activity (Corring et al., 1982). The bile acid production multiply by three during the first 20 days (Croizat and Lambiotte, 1971).

The causal agent of the mentioned change is not the weaning (i.e. the change of feeding), but the hormonal status of the organism. Corring et al. (1972) found that the prolongation of suckling period did not influence either the intestinal closure-time or the development of pancreatic amylase, lipase and chymotrypsin activity, although the lactase activity can be maintained. The fibre-starch ratio of the post-weaning feed had not any influence upon the amylase excretion by urine (Fekete et al., 1988b). On the basis of rat experiments Daniels et al. (1972), Chan et al. (1973) and Henning (1985) explain the cessation of the intestinal macromolecule uptake with the elevation of blood cortisol and thyroxine. The exogen glucocorticoid and ACTH injection stimulate the pepsinogen and pancreatic enzymes production (Courtot, 1972) as well as that of sucrose, maltase, trehalase, amino peptidase (Galand and Forstner, 1974) and alcaline phosphatase (Moog, 1953). Administration of T_4 or T_3 has also been shown to cause precocious decline of jejunal lactase activity and ileal lysosomal hydrolases (Paul and Flatz, 1983 ; Koldovsky et al., 1971) and precocious increases of jejunal sucrase and maltase (Jumawan and Koldowsky, 1978).

Although some of the data derive from rat and mouse experiments, one can state that the development of the digestive enzyme set depends upon the function of the hypophyseal-adrenal axis. The compounds of the feed (as substrates) contribute to the hormonal stimulus, stabilizing the production of the enzymes ("enzyme, stabilized by its substrate").

The main endogenic factors influencing the digestion, evaluated by digestibility trials

The digestibility of nutrients is slightly lower at the Californian than at the New Zealand White rabbit (Hullár and Gippert, 1986). No sex differences were found in respect of the digestion either at the growing or at the adult rabbit. The digestion coefficient of the protein is greater by 3.16 % at the growing rabbit than at the adults (Fekete and Lebas, 1983 ; Fekete and Bokori, 1986).

The simulated "physiologic" stress (0.5 IU ACTH/kg body weight/day im.) did not influence the digestibility of nutrients, either with or without antibiotic supplementation. At the same time the feces sodium to potassium ratio changed (Fekete, Maertens and Tölgyesi, 1988).

The ad libitum fed rabbits consume their soft feces (cecotroph) according to the "protein minus fiber" level of the ration. It means that the relative protein deficit or fiber surplus enhance, the inverse situation diminishes the cecotrophy and may modify the measured digestibility coefficient (Fekete and Bokori, 1985).

The presence of hairball in the stomach reduced the protein and fiber digestibility and resulted in a negative apparant absorption coefficient of ash, with the simultaneous elevation of the blood glucocorticoid level (Fekete and Bokori, 1986).

Future trends

The last ten, fifteen years have brought unexpected progress in rabbit's digestive physiologic research. Still, great challenges remain. In years to come, researches will probably concentrate on some of the following topics.

- Particularities of the regulation of feed and cecotroph intake.
- The process and control of the maturation of gastrointestinal tract.
- Developmental aspects of digestion : enzymatic and transport development, formation of microbial digestion of large intestine.
- Details of digestion and absorption of nutrients. The influence of physiological status (e.g. sexual cycle), presence of gastro-intestinal parasites etc.
- Further investigation of the morphology and biochemistry of rabbit's intestinal flora, its role in the digestion, possible biotechnological alterations.
- Control and integration of gastrointestinal functions with special emphasis on gastrointestinal hormones and on neural and hormonal control of intestinal ion transport.

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Summary

The rabbit is one of the most common laboratory animal, consequently there is an enormous number concerning its physiology. The present review is shrunken on a special field and deals with the new findings of the rabbit's digestive physiology. For the sake of the better intelligibility the most important antecedents are also given.

First the particularities of feed intake regulation are demonstrated. The strong control mechanism can be disturbed by feed antinutritives, mycotoxins and high environmental temperature. The cecotrophy depends upon three main factors : stimulation of rectal mechanoreceptors, perception of the specific odour of the soft feces and the inner motive determined by the blood level of metabolites and hormones.

The species characteristics of proportions, pH-conditions, microflora and -fauna of the rabbit's digestive tract are given. The digestion and absorption of feed's nutrients are discussed. Special sections deal with the sorption of electrolytes and VFAs in the gut, the cecal digestive process, the formation of hard and soft feces and the role of the cecotroph in the stomachal carbohydrate degradation.

A relatively new area, the development and maturation of the gastrointestinal tract is shown. The postnatal evolution of the digestive enzyme activity is also summarized. The main endogenic factors (bred, sex, age, stress, cecotrophy, presence of hairball in the stomach) influencing the digestion of feed's nutrients are also described. The probably future trends are given.

Résumé

Le lapin est un des plus commun animale laboratoire, en conséquence, il y a un nombre énorm concernant sa physiologie. Le résumé présent est limité sur un domaine spécial et s'occupe des acquisition récentes de la physiologie digestive du lapin. Dans l'intérêt de meilleur intelligibilité les plus importants antécédents sont aussi touchés.

D'abord les particularités de la régulation du prise d'aliment sont présentées. Le mécanisme fort peut être affaibli par des substances antinutritives et des mycotoxins de l'aliment et par une température ambiante élevée. La cécotrophie dépend fondamentalement de trois facteurs : excitation des mécanopercepteurs réctals, sensation de l'odeur spécifique de la fèces molles et de motif interne, déterminé par la teneur sanguine des métabolits et hormones.

Après l'exposition courte des caractéristiques raciales (proportion des différentes parties, conditions de pH, la flore et faune microbienne) sections séparées s'occupent de la sorption des électrolytes et AGVs dans l'intestine, de la digestion cécale, la formation des crottes molles et dures et du rôle des cécotrophes dans la dégradation stomacale des glucides.

Les résultats de la relativement nouvelle direction de la recherche, s'occupant du développement et de la maturation du système gastrointestinal sont aussi analysées. L'évolution postnatale de l'activité des enzymes digestives est résumé. Les plus emportants facteurs endogènes, influencant la digestion des nutriments (race, sex, age, stress, cécotrophie, trichobézoar dans l'estomac) sont récapitulés. Les tendances probables sont esquissées.