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COMPARATIVE MORPHOMETRIC AND HISTOLOGICAL ANALYSIS OF THE STOMACH IN ADULT GUINEA PIGS (*CAVIA PORCELLUS*) AND WHITE RATS (*RATTUS NORVEGICUS*)

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ABSTRACT

The understanding of rodent gastrointestinal morphology is important for several medical applications, including experimental surgical procedures, the diagnosis of gastric disorders, and providing information about diet adaptation and gut physiology. Therefore, the present study aimed to investigate the anatomical, morphometric, and microscopic characteristics of the gastric mucosa in adult guinea pigs and white rats. Stomachs from five healthy adult guinea pigs (*Cavia porcellus*) and five white rats (*Rattus norvegicus*) were collected and preserved in 10% formalin. The samples were later processed, sectioned, and stained with Harris Hematoxylin and Eosin. Microscopic measurements were made for the depth of gastric pits, diameter of gastric glands, and the thickness of the gastric mucosa, tunica submucosa, tunica muscularis, and tunica serosa. The number of parietal and chief cells was counted in the fundic and pyloric regions of both animals. The rat stomach was crescent-shaped, with distinct non-glandular and glandular regions. In contrast, the stomach of guinea pig was pear-shaped and totally glandular. Stomach microstructure exhibited variations in thickness and morphology. The rat's non-glandular mucosa had keratinized squamous epithelium, while the guinea pig lacked a non-glandular region. Histologically, gastric pits and glands differed in size, density, and cellular composition, with guinea pigs showing thicker muscular layers and larger, less dense glands, while rats had more parietal and chief cells in the fundic and pyloric regions. This study enhances the understanding of how dietary habits shape gastric anatomy and physiology. Future research could explore enzymatic activity, gut microbiota interactions, developmental anatomy, and molecular mechanisms underlying these adaptations.

Keywords: *Anatomy, Histology, Guinea Pig, Rat, Stomach*

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INTRODUCTION

Digestive diseases represent a significant portion of clinical emergencies worldwide. According to the Centers for Disease Control and Prevention (CDC), diagnostic visits for these conditions reach 7.9 million annually (CDC, 2013 and 2010). Rodents, due to their genetic, physiological, and anatomical similarities to humans, are considered the best animal models for studying human diseases (Guo *et al*., 2012: Szpirer., 2020). Among rodents, laboratory rats and guinea pigs are recognized as optimal biological models for studying the pathological mechanisms in various gastrointestinal disorders (Musser, 2024).

The understanding of rodent gastrointestinal morphology is important in several medical applications, including experimental surgical procedures (Natale *et al*., 2001). Morphometric studies of the gastric mucosa are important in the diagnosis of gastric ulcers (Tack and Pandolfino, 2018). Furthermore, quantitative analyses of gastric muscle and its arrangement contribute to the diagnosis of a range of disorders, including gastric reflux, dyspepsia, gastroparesis, pyloric stenosis, and rapid gastric emptying (Keller *et al*., 2018: Nwafor and OM'Niabohs., 2014). The microscopic features of the stomach provide valuable information in diet adaptation and gut physiology (Rickard and Dorough, 1984). Studies on stomach morphology in rats and guinea pigs provide vital understanding of acidity-related gastric cancers and in vivo nitrosocarbamates formation in the human stomach (Ghoshal and Bal., 1989).

Both rats and guinea pigs, which belong to the order *Rodentia* and the families *Muridae* and *Caviidae*, respectively, exhibit distinct feeding practice: rats are omnivorous, while guinea pigs are strict herbivores (Igbokwe and Obinna, 2016). The morphology and functionality of the stomach are influenced by the nature of food, food intake frequency, food storage mechanisms, and overall body shape and size (Vdoviaková *et al*., 2016).

Basic studies for stomach morphology among different rodent species were conducted by Ghoshal and Bal. (1989). However, they overlooked several important morphometric and microscopic details. Other studies were conducted among *Muridae* (rats and mice) (Walters *et al*., 2014), *Leporidae* (rabbits) (Florin., 2013), and *Caviidae* (guinea pigs) (Abd AL-Rahman, 2016).

This study provides the first morphometric and microscopic comparison of stomach anatomy between guinea pigs (*Cavia porcellus*) and rats (*Rattus norvegicus*), linking these structural differences to their distinct dietary adaptations. By quantifying parameters such as gastric layer thickness, glandular density and parietal and chief cell quantities in the fundic and pyloric regions, we illustrate how dietary habits (herbivory and omnivory) shape the anatomical features of the rodent stomach. Therefore, the current study intended to investigate the comparative morphometric and histological features of the stomach in the adult guinea pigs (*Cavia porcellus*) and white rats (*Rattus norvegicus*).

MATERIALS AND METHODS

Study animals

Five healthy adult guinea pigs (*Cavia porcellus*) and five white rats (*Rattus norvegicus*) were employed in this study with weights ranging between (532-612 g) and (200-235 g) respectively. They were obtained from certified animals' breeders in the city of Mosul-Iraq. The animals housed during the investigation in appropriate cages with free food and water access. The study performed in the laboratory of the Anatomy Department, College of Veterinary Medicine, University of Mosul-Iraq, during October 2024 – February 2025. Sex differences were not considered in this study.

Animal preparation and ethical approval

The experimental animals were handled with care adhering to animal rights ethics. Euthanasia was achieved by intraperitoneal injection of 130 mg sodium thiopental (Pentothal®, Hospira, USA) in the lower right quadrant of the abdomen in both types' animals, corresponding with (AVMA) guidelines (Underwood and Anthony, 2020). The study was approved by Institutional Animal Care and Use Committee of the college of Veterinary Medicine at University of Mosul, Iraq under reference number of UM.VET.2024.019

The animals were weighed using a sensitive weighing scale (EK-IEW-I, Japan), then the animals were fixed with pins penetrated through the limbs, an incision was made from the neck anteriorly to the genital area posteriorly, and another transvers incision made perpendicularly along the length of the limb and the skin was folded laterally. An incision through the abdominal wall proceeded laterally on both sides to cut the rib cage, the abdominal viscera were exposed, and stomach photographed and examined in situ and the whole digestive system was eviscerated outside of the body (Johnson-Delaney., 2006).

Morphological measurements

Stomach samples from both animals were collected, washed and gastric contents were gently removed. The total weight was taken, the length of stomach at lesser and greater curvatures, the diameter of stomach at the cardiac, fundic and pyloric regions, and the diameter of the cardiac and pyloric openings. Later, samples were kept in labeled containers filled with 80 ml of 10% formalin for 72 hours until complete fixation (Carson and Cappellano., 2015).

Histological processing

After fixation, the specimens were subjected to dehydration by immersing in ethyl alcohol solutions with concentrations of 70%, 80%, and 95% for 30 minutes each. Subsequently, they were placed in 100% alcohol for 45 minutes.

Next, the specimens were cleared in xylene for 50 minutes and were then embedded in wax (paraffin) in two changes for 1.5 hours each. Subsequently, the specimens were molded into a paraffin block and sliced into 4 µm thick sections using a rotary microtome (BIOBASE BK-2218, China).

The sections were stained with Harris hematoxylin and eosin. Then, the slides mounted by DPX and cover slipped. Later, the stained slides were assessed under a light microscope (Olympus-CX21, Japan) (Carson and Cappellano., 2015).

Histomorphometric measurements

A series of images was captured for the selected tissue sections. These images were obtained using an 18.0 MP OMAX digital camera equipped with the light microscope. Afterwards, measurements and image processing were carried out using ImageJ software (version 1.53, NIH, USA). Eight histological sections were randomly chosen for analysis, and measurements were conducted across 15 microscopic fields. These measurements included the depth of gastric pits, dimeter of gastric glands, thickness of the gastric mucosa, tunica submucosa, tunica muscularis and tunica serosa. The cells were counted manually in 100 µm2 fields at 400X magnification in the fundic and pyloric regions in both animals.

Statistical analysis

The data from macroscopic and microscopic measurements were organized and summarized as a mean and standard error of the mean (M ± SEM), Furthermore. Significant differences between the morphological parameters analyzed with Student's t-test for independent variables, the statistical analysis performed using (IBM. Spss V27, UK) software at $P \geq 0.05$

RESULTS

The rat stomach exhibited a crescent shape, located in the left upper region of the abdominal cavity. It was situated caudal to the diaphragm and dorsal to the medial lobe of the liver, aligned with the first lumbar vertebra. On the other hand, the guinea pig stomach was a curved pear shape, occupying the upper left abdominal cavity and positioned dorsal to the liver, cranial and medial to the small intestine, and caudal to the diaphragm. The rat stomach was characterized by two distinct regions: a non-glandular portion, which appeared thin-walled and white, and a glandular portion, which was thicker and gray in color. In contrast, the guinea pig stomach was entirely glandular and uniformly grayish in color (Fig. 1A & B).

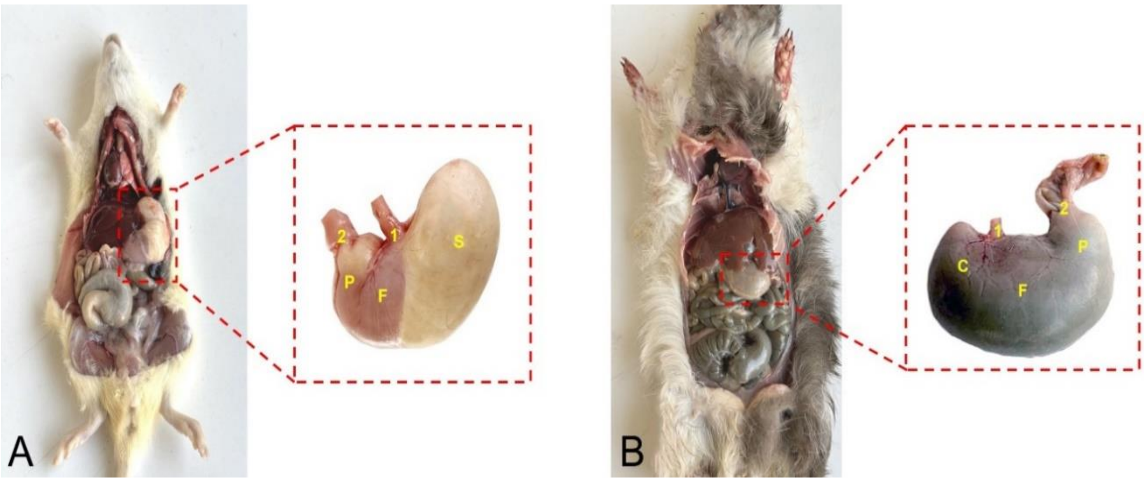

Fig. 1: The figure illustrates the position of the stomach within the abdominal viscera in the rat (A) and guinea pig (B), and the different gastric regions, including the cardia (C), fundus (F), pylorus (P), and forestomach (S), along with the cardiac opening (1) and pyloric opening (2).

The total weight of the stomach was between 3-4.5 grams in both animals, showing no significant differences. However, the relative weight of the rat stomach was significantly greater than the guinea pig stomach at ($P \leq 0.05$) because the lower rats' body weight (Table 1).

The stomach was longer in the guinea pig compared to the rat. The greater and lesser curvatures were significantly longer in the guinea pig compared to the rat stomach. The forestomach in the rat forms 1/3 of the whole stomach space with a diameter reaching 15.11 mm. While, there was no forestomach in the guinea pig, the guinea pig stomach has a developed small cardiac region while this region is not clear in the rat stomach. Both animal stomachs have fundic and pyloric regions. The diameter of the fundus region was greater in the guinea pig stomach compared to the rat stomach ($P \leq 0.05$). While the diameter of the pyloric region was similar in both animals (Table 2) (Fig. 2A & B).

The gastric mucosa in the rat stomach showed prominent short folds (rugae) near the cardiac opening and in the fundic region. The number of these rugae was fewer than those seen in the guinea pig stomach, where the rugae were longer, more numerous, and higher, covering most of the cardiac region.

The microscopic observations revealed that the wall of the stomach was composed of four main layers or tunics: the mucosa, submucosa, muscularis, and the serosa in most gastric regions in both animals.

Table 1: The relative weight in rat and guinea pig stomach

Animal	Body weight (g.) M ± SEM	Stomach weight (g.) M ± SEM	Relative weight (%.)
Rat	221 ± 14.03	4.60 ± 0.71	2.08 % *
Guinea pig	572 ± 40.01	3.70 ± 0.35	0.64 %

*: indicate significant statistical differences between both animals

Table 2: Gross dimensional measurements of the stomach in rats and guinea pigs

Animal	Length of greater curvature M ± SEM	Length of lesser curvature M ± SEM	Diameter of forestomach M ± SEM	Diameter of fundic region M ± SEM	Diameter of pyloric region M ± SEM	Diameter of cardiac opening M ± SEM	Diameter of pyloric opening M ± SEM
Rat	37.97 ± 0.45	8.25 ± 0.41	15.11 ± 0.37	15.90 ± 0.19	18.02 ± 0.32	5.42 ± 0.04*	3.14 ± 0.14
Guinea pig	42.17 ± 0.19*	15.98 ± 0.22*	Null.	18.06 ± 0.45*	16.60 ± 0.28	4.22 ± 0.21	4.45 ± 0.44

The dimensions were measured per mm.
*: indicate significant statistical differences between both animals

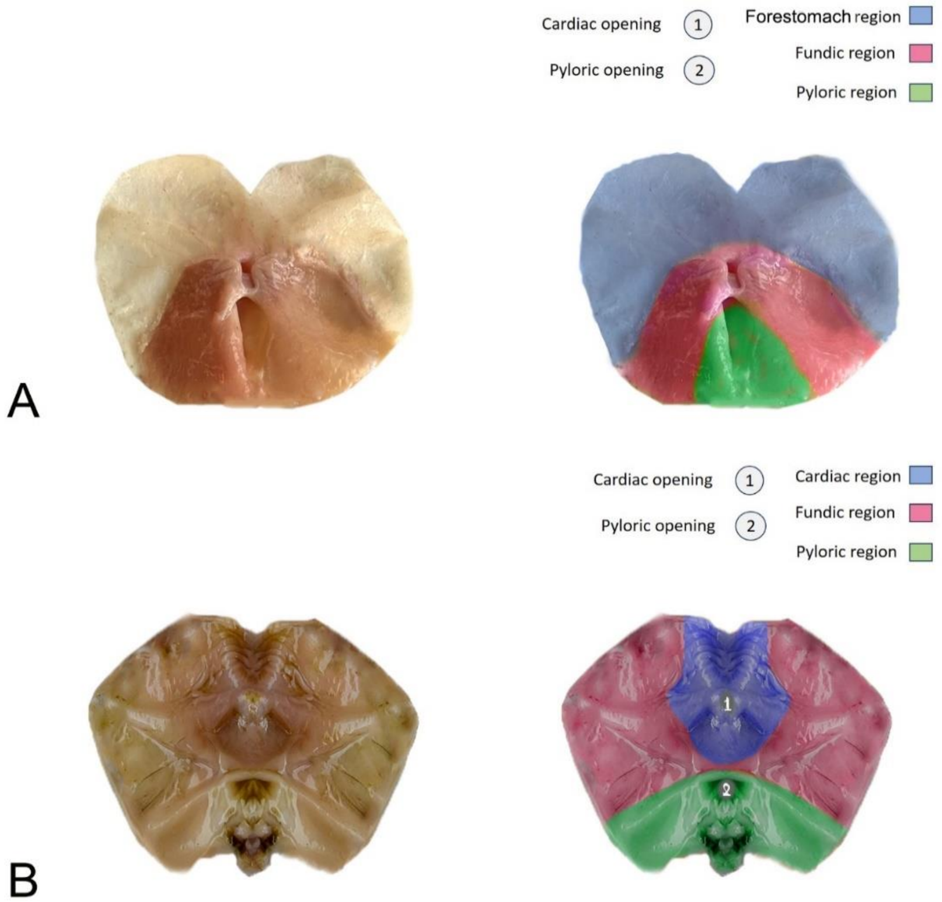

Fig. 2: The figure illustrating the gastric mucosa in different gastric regions in the rat (A), and guinea pig (B). Each color represents different gastric region, the dissection was performed along the greater curvature, stomachs oriented craniocaudally.

The gastric mucosa in rats was covered with thick keratinized stratified squamous epithelium in the forestomach region. The thickness varied from very thick in the limiting ridge to multiple thin layers of cells in the rest of this part. The total thickness of the wall was 212.98±5.65 µm, the thickness of stratified squamous epithelium was 92.07±1.47 µm, while the thickness of the submucosal layer was 52.50±3.91 µm, the thickness of muscular layer was 51.12±1.11 µm and the thickness of the serosal layer was13.62±0.73 µm (Fig 3).

The glandular mucosa of the fundic and pyloric regions was lined with a simple columnar epithelium that extended into gastric pits. The pits varied in depth, being shorter in the fundic region and deeper in the pyloric region. The lamina propria contained branched and simple tubular gastric glands, with lower density in the apical region and higher density in the basal region. These glands were composed of four cell types: zymogenic, large eosinophilic parietal, and mucous neck

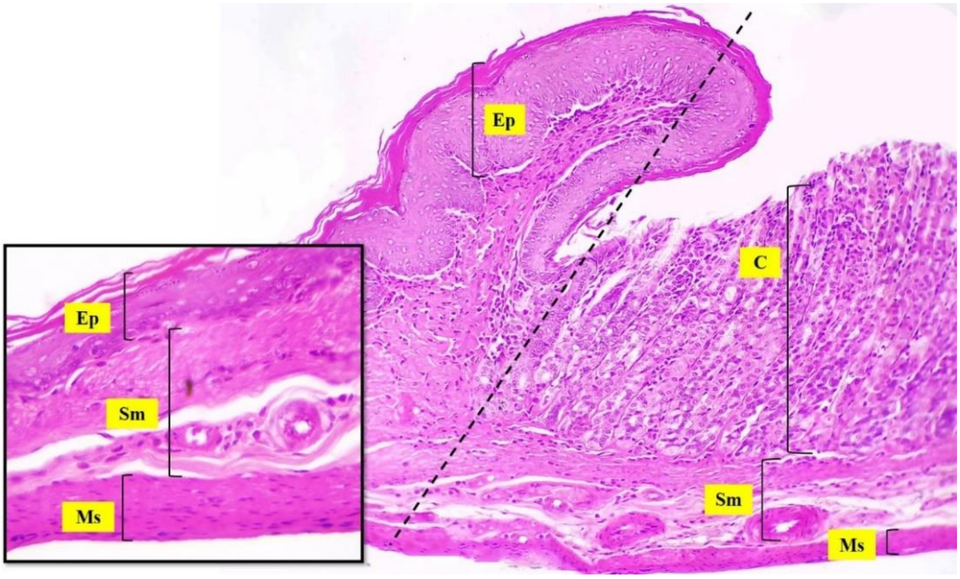

Fig. 3: A microphotograph shows the limiting ridge (dashed line) between glandular and non-glandular stomach in rat, covered with thick keratinized stratified squamous epithelium (Ep), the magnified figure shows the forestomach histological layers including: the mucosal epithelium (Ep), submucosa (Sm), and the muscular layer (Ms), (H&E, 100X, magnified fig, 400X).

The muscularis mucosae was present beneath the mucosa, and constituted a thin layer of smooth muscle fibers, while the submucosa was a thin layer of loose connective tissue containing blood and lymph vessels.

The muscular layer consisted of an inner circular and an outer longitudinal layer. This layer was thicker in the glandular regions compared to the non-glandular regions. The serosal layer was composed of mesothelial epithelium and submesothelial connective tissue (Fig. 4 A & B).

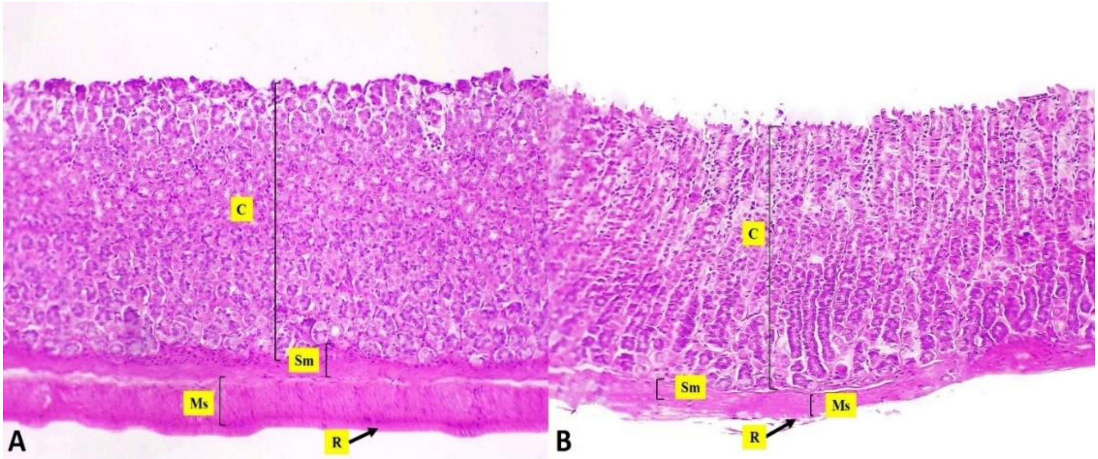

Fig. 4: The microphotograph shows the fundic (A) and pyloric regions (B) of the rat stomach. The figure focus on the histological layers of the glandular stomach, including the mucosa (C), submucosa (Sm), muscular layer (Ms), and serosa (R). (H&E, 100X).

The microscopic structure of guinea pig stomach was similar to that of rats, except that the non-glandular portion was absent with the presence of a small cardiac region (Fig 5 A &B).

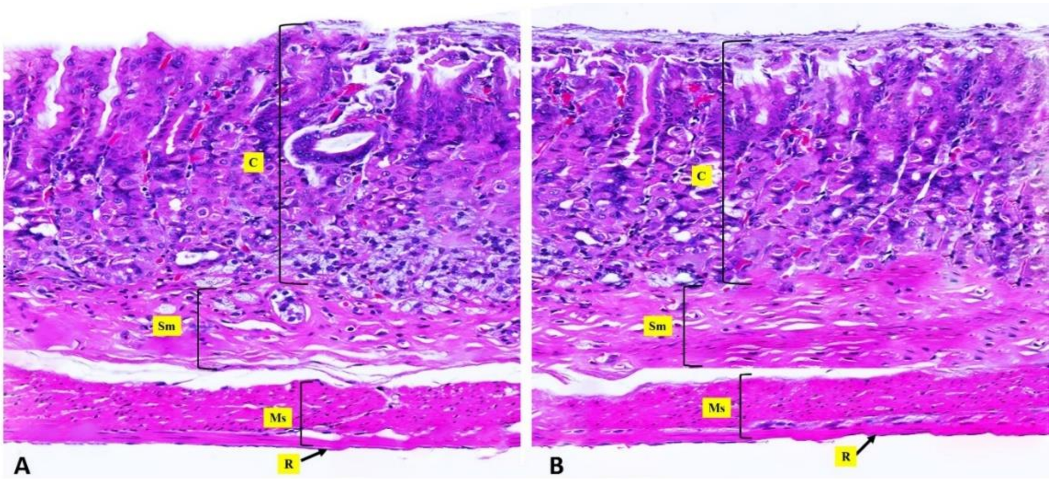

Fig. 5: The microphotograph shows the fundic (A) and pyloric regions (B) of the guinea pig stomach. The figure shows the histological layers of the glandular stomach, including the mucosa (C), submucosa (Sm), muscular layer (Ms), and serosa (R). (H&E, 100X).

The histomorphometric measurements of gastric microcomponents revealed that the total thickness of the gastric wall was significantly thicker in the fundic and pyloric regions of the guinea pig stomach compared to rats. In the fundic region, the mucosal layer was thicker in rats than in guinea pigs ($P \leq 0.01$), while the muscular and serosal layers were significantly greater in the guinea pig stomach than in rats. The diameter of the gastric glands was wider ($P \leq 0.01$) in the guinea pig stomach than in the rat stomach. However, the gastric pits showed no statistical differences (Table 3 and Table 4).

Table 3: Total thickness of the fundus and pylorus in rat and guinea pig stomachs

Animal	Total thickness of the fundus wall (µm.) M ± SEM	Total thickness of the pylorus wall (µm.) M ± SEM
Rat	515.97 ± 5.64	408.88 ± 5.23
Guinea pig	604.65 ± 5.58*	525.25 ± 2.82*

*: indicate significant statistical differences between both animals

Table 4: Thickness of histological layers in the fundic region of the rat and guinea pig stomachs

Fundic reg.	Thickness of mucosa M ± SEM	Thickness of submucosa M ± SEM	Thickness of muscular layer M ± SEM	Thickness of serosal layer M ± SEM	Diameter of gastric glands M ± SEM	Length of gastric pits M ± SEM
Rat	373.73±6.71*	73.40 ± 4.76	79.66 ± 2.51	15.35 ± 0.73	39.39 ± 2.15	74.65 ± 2.99
Guinea pig	297.91 ± 2.82	81.51 ± 1.28	192.06 ± 1.60*	20.64 ± 1.03*	45.92 ± 2.09*	81.85 ± 3.14

The dimensions were measured per µm.
*: indicate significant statistical differences between both animals

In the pyloric region, the mucosal layer exhibited significant differences (P≤0.01) between rats and guinea pigs. The submucosal layer was similar in both animals. The muscular layer was thicker in the guinea pig's pyloric region compared to the rat stomach. The gastric glands were wider in the guinea pig, and the gastric pits were deeper than in rats (Table 5).

The density of gastric glands varied in the fundic and pyloric regions between the two animals. In the rat stomach, the glands were densely arranged within the mucosal layer, while in the guinea pig stomach, the glands were larger and exhibited lower density.
The number of parietal and chief cells in the gastric glands also showed a significant difference between rat and guinea pig stomach. The parietal cells were slightly higher in the fundic and pyloric regions in the rat stomach compared with guinea pig, while the chief cells were higher in the fundic region and evenly matched in the pyloric region (Fig. 6) (Table 6).

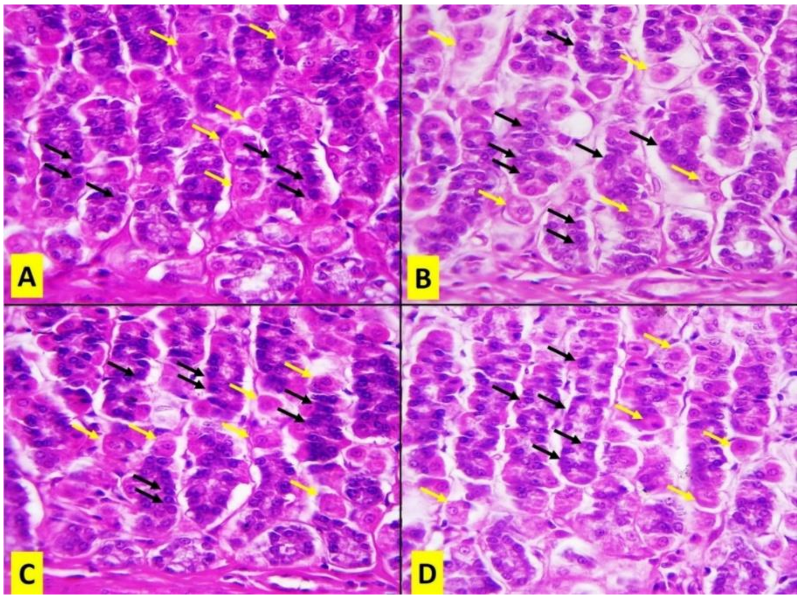

Fig. 6: The microphotograph shows the gastric glands in the fundic (A) and pyloric (B) regions of the rat stomach, as well as the fundic (C) and pyloric (D) regions of the guinea pig stomach. The figure highlights the parietal cells (yellow arrows) and chief cells (black arrows). (H&E, 400X).

Table 5: Thickness of histological layers in the pyloric region of the rat and guinea pig stomachs

Animal pyloric reg.	Thickness of mucosa M ± SEM	Thickness of submucosa M ± SEM	Thickness of muscular layer M ± SEM	Thickness of serosa M ± SEM	Diameter of gastric glands M ± SEM	Length of gastric pits M ± SEM
Rat	395.93±5.15*	72.03 ± 4.76	54.04 ± 3.66	14.84 ± 1.67	39.13 ± 1.19	120.72 ± 2.98
Guinea pig	240.90 ±1.21	82.18 ± 1.28	161.67 ± 1.65*	17.91 ± 1.03	58.05 ± 2.09*	192.21 ± 5.10*

The dimensions were measured per µm.
*: indicate significant statistical differences between both animals

Table 6: Number of parietal and chief cells in the fundic and pyloric regions in rat and guinea pig stomachs

Animal	Fundic region		Pyloric region	
	No. of parietal cells	No. of Chief cells	No. of parietal cells	No. of parietal cells
rat	7.8 ± 0.48*	35.6 ± 0.1.36*	6 ± 0.31	33 ± 1.92*
Guinea pig	6.5 ± 1.18	28.1 ± 0.92	5.3 ± 0.72	27 ± 1.36

*: indicate significant statistical differences between both animals

DISCUSSION

The present study intended to investigate the anatomical, morphological and microscopic aspects of the stomach in the adult guinea pigs and white rats. The current study showed that the rat stomach had a crescent shape, located in the left upper abdominal cavity, caudal to the diaphragm and dorsal to the liver, and had two regions: a thin-walled, non-glandular white portion and a thicker, glandular gray portion. While the guinea pig stomach was pear-shaped, entirely glandular, and uniformly gray, positioned in the upper left abdominal cavity, dorsal to the liver. Similar observations regarding the shape and location were noticed in rats by Di Natale *et al.* (2022) and Matsukura et al. (1985), and by Raja (2022) and Stan (2018) in guinea pigs. Vdoviaková *et al.* (2016) found that the stomach of a rat was a curved semi-lunar shape, located on the left side of the abdominal cavity close to the level of the last rib and first lumbar vertebra, dorsally to the liver. Raja (2022) found that the stomach in guinea pigs was C-curved in shape, situated on the upper left side of the abdominal cavity behind the liver and diaphragm.

The present study showed that the relative weight of the rat stomach was significantly greater than the guinea pig stomach, with a similar value recorded by Vdoviaková *et al.* (2016) in rat and by Al-Shreefy (2024) in guinea pig stomach. The differences come from differences in total body weight and size between both animals. The bigger and heavier animal shows the smaller relative gastric weight. According to Kleiber's law (1932): it is established that metabolic rate scales to the 3/4 power of body mass. This indicates that larger animals have a lower metabolic rate per unit of body weight, reducing the need for proportionally larger digestive organs. (Chivers & Hladik, 1980), found that relative stomach size decreases with increasing body size, reflecting adaptations to dietary and metabolic demands.

The gastric dimensions were larger in guinea pig stomach compared with rat. This included the greater and lesser curvatures and the diameter of the fundic and pyloric regions. These morphological differences were because guinea pigs are obligate herbivores with adopted greater capacity stomachs to accommodate larger volumes of plant matter. Furthermore, guinea pigs tend to graze throughout the day, requiring a stomach capable of holding larger food quantities temporarily while rats, as omnivores, consume smaller meals, resulting in a relatively smaller stomach size (Kararli 1995).

Microscopic observations in the current study revealed that the wall of the stomach was composed of four layers: mucosa, submucosa, muscularis, and serosa in most gastric regions in both animals. The mucosa in the rat forestomach (non-glandular) region was covered with a thick cornified squamous epithelium. The glandular region was lined by a single row of simple columnar epithelia. Corresponding observations reported by (Matsukura *et al.,* 1985; Ofusori and Caxton-Martins., 2008).

The stomach in guinea pigs was entirely glandular and there was no forestomach (non-glandular) portion with the presence of a small cardiac area. The histo-morphometric measurements of the total thickness of the gastric wall were significantly thicker in the fundic and pyloric regions of the guinea pig stomach. In the fundic region, the mucosal layer was thicker in rats than in guinea pigs, whereas the muscular and serosal layers were significantly thicker in the guinea pig stomach than in rats. The measurement data were closer to those of (Zhu and Wang., 2016) in adult rats and (Al-Shreefy., 2024) in guinea pigs. Histological differences were attributed to the functional and developmental evolutionary characteristics in both animals.

The gastric glands were wider in the guinea pig than in the rat stomach. While, the gastric pits showed no statistical differences. These variances are attributed to the secretary activity and dietary specialization, since fibrous plant material requires more extensive enzymatic digestion in guinea pigs' stomach, while rats are adapted for temporary storage and microbial fermentation (Kararli., 1995: Al-Shreefy., 2024).

Karasov, & Martínez., (2007) and Stevens & Hume., (2004) also explain that the structure of the stomach in animals is shaped by a combination of habitat-driven dietary adaptations and genetic factors. Habitat influences the type of food available, which drives evolutionary adaptations in stomach anatomy (e.g. glandular density, muscular thickness). Genetic variability determines the basic structure of the stomach and how it responds to environmental pressures. Together, these factors explain why species like guinea pigs (herbivores) and rats (omnivores) have evolved distinct stomach structures suited to their ecological niches.

The gastric glands from both animals were simple tubular, composed of zymogenic, parietal, mucous neck, and enteroendocrine cells. The density of the gastric glands varied in the fundic and pyloric regions between the two animals. In the rat stomach, the glands were smaller and densely arranged within the mucosal layer, whereas in the guinea pig stomach, the glands were larger and exhibited lower density. Similar findings are mentioned by (Zhu and Wang., 2016) in albino rats and by Al-Shreefy (2024) in guinea pigs. The authors mention that nucleus-glandular index and glandular cell density were greater within the mucosal area in the rat stomach compared with guinea pig.

CONCLUSIONS

The present study provides a detailed comparative analysis of the anatomical, morphological, and microscopic features of the stomach in adult guinea pigs and white rats aligned with their dietary adaptations. The findings showed that guinea pig's stomach is entirely glandular, larger, and structurally suited for its herbivorous grazing habits, while the rat's stomach has both glandular and non-glandular regions, adapted for omnivorous feeding. Microscopic analysis showed variations in layer thickness and glandular arrangement. This study enhances understanding of how dietary habits shape gastric anatomy and physiology in nutrition planning, and the use of these species as research models. Future research could explore enzymatic activity, gut microbiota interactions, developmental anatomy, and molecular mechanisms underlying these adaptations. These findings also pave the way for comparative evolutionary studies, disease modeling and their impacts on gastrointestinal health.

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تحليل تشريحي مقارن للمعدة في خنازير غينيا والجرذان البيضاء: دراسة قياسية شكلية ومجهرية

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تعد الدراسة الشكلية للجهاز الهضمي في القوارض مهمة في العديد من التطبيقات الطبية، بما في ذلك االتجارب الجراحية وتشخيص امراض الجهاز الهضمي، وتوفير معلومات حول التكيف الغذائي. لذلك، هدفت الدراسة الحالية إلى تحري الخصائص التشريحية والقياسية والمجهرية للمعدة في خنازير غينيا والجرذان البيضاء. تم جمع العينات من خمسة خنازير بالغة سليمة (*Cavia porcellus*) وخمسة جرذان بيضاء (*Rattus norvegicus*) وحفظها في محلول الفورمالين ١٠ ٪. تم تمرير الأنسجة وأجري تقطيع نسيجي للعينات وصبغت بملون هاريس هيماتوكسيلين وايوسين. تم إجراء القياسات المجهرية لدراسة عمق وهدات واقطار الغدد المعدية ، وسمك الغشاء المخاطي في المعدة، والغلالة تحت المخاطية، والغلالة العضلية، والغلالة المصلية. وحسبت اعداد الخلايا الجدارية والخلايا الرئيسة في المنطقة القاعية والبوابية لكلا الحيوانين. اتخذت المعدة في الجرذان شكل هلالي مكون من جزئين غدي وغير غدي. في المقابل، كانت المعدة في الخنزير كمثرية الشكل وغدية بصورة كاملة . أظهرت البنية المجهرية للمعدة اختلافات في السمك والتركيب. اذ كان الغشاء المخاطي غير الغدي في الفأر مبطناً بظهارة حرشفية متقرنة، بينما كانت المعدة الغدية في خنازير غينيا مبطنة بظهارة مكعبة بسيطة، اختلفت الوهدات المعدية والغدد في الابعاد والكثافة والتركيب الخلوي، حيث أظهرت خنازير غينيا طبقة عضلية أكثر سمكا وغددا أكبر وأقل كثافة ، بينما كان لدى الجرذان خلايا جدارية ورئيسة أكثر في المناطق القاعية والبوابية. تعزز هذه الدراسة فهم تأثير التكييف الغذائي على تشريح المعدة في القوارض. كما تمهد هذه النتائج الطريق للدراسات التطورية المقارنة وفهم آلية حدوث الأمراض وتأثيراتها على صحة الجهاز الهضمي.