Developmental changes of jejunal brush-border enzyme activity in growing Jinhua gilts

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ABSTRACT

The present study was aimed to investigate the developmental changes of small intestinal morphometry and jejunal brush-border enzyme activity in growing Jinhua gilts. The weight, length, and mucosa weight of the small intestine were measured at 35, 80 and 125 days of age, respectively. Sucrase, maltase, lactase and alkaline phosphatase (ALP) activities of the jejunal brush-border membrane were determined at the respective stages. Body weights and body weight gains significantly increased with age (P<0.05). Weights of the small intestine and of the intestinal mucosa increased faster from 35 to 80 d than from 80 to 125 d (P<0.05). Weights of the duodenum, jejunum, and ileum, and mucosa from the respective sections increased with age (P<0.05). Mucosa weight relative to the weight of the section was greater (P<0.05) for the duodenum, jejunum than for the ileum. Jejunal maltase and sucrase activity increased with age (P<0.05), whereas, lactose and ALP activity decreased with age (P<0.05) during growth. There was a 15-fold increase in both total jejunal maltase and sucrase activity from 35 to 125 days of age, and a 5-fold increase in both total jejunal lactase and ALP activity; the greatest rate of increase occurred between 35 and 80 days of age. The results suggest increases in body weight of growing Jinhua gilts are accompanied by significant developmental changes in intestinal weight, length and mucosal weights as well as jejunal brush border maltase, sucrase, lactase and ALP activities.

Key words: Small intestinal morphometry, Hydrolase, Jinhua gilts, Developmental change.

RIASSUNTO

CAMBIAMENTI NELLO SVILUPPO DELL’ATTIVITÀ ENZIMATICA DEI MICROVILLI DELL’INTESTINO TENUE IN SCROFETTE IN ACCRESCIMENTO DI RAZZA JINHUA

Scopo del presente studio è stato quello di ricercare le variazioni morfometriche dell’intestino tenue e l’attività enzimatica dei microvilli intestinali in scrofette di razza Jinhua in accrescimento. Dell’intestino tenue sono stati misurati, al 35\(^{\circ}\), 80\(^{\circ}\) e 125\(^{\circ}\) giorno di età, il peso, la lunghezza e il peso della mucosa. L’attività enzimatica dei microvilli intestinali del digiuno è stata rilevata nei medesimi giorni attraverso...
la determinazione della quantità di saccarasi, maltasi, lattasi e fosfatasi alcalina (ALP). Il peso medio e l’incremento ponderale sono aumentati significativamente con l’età (P<0,05). Il peso del piccolo intestino e della mucosa intestinale sono cresciuti maggiormente nell’intervallo tra il 35o e l’80o giorno rispetto alla fase successiva (80-125 d) (P<0,05). Il peso di duodeno, digiuno e ileo e della rispettiva mucosa sono aumentati con l’età (P<0,05). Il peso relativo della mucosa è risultato maggiore (P<0,05) nel duodeno e nel digiuno rispetto all’ileo. Le attività saccarasicca e maltasicca nel digiuno sono aumentate con l’età (P<0,05), mentre le attività lattasicca e fosfatasicca sono diminuite durante l’accrescimento (P<0,05). È stato rilevato un incremento pari a 15 volte dell’attività enzimatica totale di maltasi e saccarasi dal 35o al 125o giorno di età e di 5 volte dell’attività enzimatica totale di lattasi e fosfatasi; l’aumento maggiormente significativo si è registrato tra il 35o e l’80o giorno. I risultati evidenziano la relazione tra l’incremento del peso medio delle scrofette Jinhua in accrescimento e lo sviluppo del tratto intestinale per quanto concerne il peso e la lunghezza dell’intestino, il peso della mucosa intestinale e l’attività enzimatica dei microvilli intestinali nella secrezione di maltasi, lattasi, saccarasi e fosfatasi alcalina.

Parole chiave: Morfometria intestino tenue, Idrolasi, Scrofette Jinhua, Cambiamenti nello sviluppo.

Introduction

The growth of an animal depends in part on its capacity to digest and assimilate ingested macromolecules, and any impairment of this is expected to constrain growth (Adeola and King, 2006). Intestinal digestion is mainly carried out by enzymes bound to the microvillus membrane of absorptive cells. Major mechanisms associated with absorptive cells are the digestion and transport of nutrients from the small intestine into the circulatory system (Brazier et al., 2001). The disaccharidases are integral carbohydrates of the small intestinal brush border membrane, responsible for the hydrolysis of carbohydrates which must occur prior to monosaccharide absorption (Lorenzsonn et al., 1987). They are located on or within the microvilli and protrude on the outer luminal surface of the intestinal cell membrane (Nieminien et al., 2001). The most important disaccharidases in mammals are lactase, sucrase and maltase. Disaccharidases and ALP are important constituents of the microvillus membrane and changes in their activities could result in reduced absorption of nutrients (Jang et al., 2000). Investigations of postnatal development of small intestinal hydrolase have been reported in ducks, chickens and pigs (Engstrom et al., 1979; Soriane and Planas, 1998; King et al., 2000; Fan et al., 2002) and have observed age related distinctions. In the current study, the observations are extended for both morphometry and hydrolases to Jinhua pigs between the ages of 35 and 125 days. The Jinhua pig is one of the most important Chinese local varieties characterized by high reproductive performance, but low growth rate and strong fatty deposition. Jinhua pigs could be slaughtered with body weight of 75-80 kg at the age of 240 days, and the meat of Jinhua pigs is the excellent raw material of Jinhua ham. Therefore, the aim of this study was to investigate developmental changes of digestive capacity in growing Jinhua gilts using weights, linear dimensions of each section of the small intestine, and jejunal brush-border enzyme activity as response criteria.

Material and methods

Animals and diets

This study was approved by the Institutional Animal Care and Use Committee of Zhejiang University. The intestinal morphometric measurements and mucosa samples in these studies were collected from 18 purebred Jinhua gilts (weaned at 28 days of age). All pigs had ad libitum access to experimental
diet and water via nipple drinkers. The feeding experiment lasted 90 days (from 35 to 125 days of age) after a 7-day of adaptation period. The experimental diets were formulated to meet the NRC (1998) nutrient requirements for the different growth phases. During the period from 28 to 125 days of age, the experimental diet offered to pigs was shown in Table 1. Crude protein, calcium and phosphorus contents of experimental diet were analysed according to AOAC (2003) procedures. Lysine content was determined by High Performance Liquid Chromatography (Hitachi L-8800 Amino Acid Analyzer, Tokyo, Japan).

**Sample collections**

Six purebred Jinhua gilts were randomly selected at 35, 80, and 125 days of age, respectively. The gilts were removed at 10 00 and killed immediately by i.p. injection of an overdose of pentobarbital (80mg/kg BW). The abdominal cavity was opened and the entire small intestine was dissected free of its mesentery and immediately placed on ice. The segment from the pylorus to the ligament of Treitz was considered as the duodenum; the segment from the junction with jejunum to the junction with cecum was considered as the ileum; and the remaining part of the small intestine was considered as the jejunum. Each segment was weighed and its length was measured. The isolated intestinal segments were divided into sections. The sections were opened longitudinally, and mucus was removed by patting with paper towels. The mucosa was collected by scraping the luminal surface firmly with glass slides that were placed over ice. The

| Table 1. Ingredients and nutrients of the experimental diets (kg⁻¹ feed). |
|-----------------|-----------------|
| **Item**        | 28-80 d         | 80-125 d        |
| Ingredients (g/kg): |
| Corn            | 719.5           | 793.9           |
| Soybean         | 240.0           | 170.0           |
| CaHPO4          | 17.0            | 12.0            |
| Limestone       | 7.0             | 8.0             |
| Salt            | 4.0             | 4.0             |
| L-lysine.HCL    | 2.5             | 2.1             |
| Premixa         | 10.0            | 10.0            |
| Nutrientsb:     |                 |                 |
| DE MJ/kg        | 13.75           | 13.79           |
| CP g/kg         | 177.8           | 150.7           |
| Ca              | 7.1             | 6.3             |
| P               | 6.1             | 5.1             |
| Lysine          | 9.6             | 7.7             |

aProvided the following (unit/kg): Cu: 10 mg, Fe: 80 mg, Mn: 30 mg, Zn: 80 mg, I: 0.5 mg, Se: 0.3 mg. Vit. A: 5850 U, Vit. D₃: 1251 U, Vit. E: 20 U, Vit. K₃: 1.86 mg, Vit. B₁₂: 3 mg, riboflavin: 3.6 mg, Vit. B₆: 1.5 mg, Vit. B₁₂: 20 µg, pantothenic acid: 18 mg, niacin: 26 mg and choline: 56 mg.

bAll data were analysed values except digestible energy which was calculated using swine NRC (1998) values.
mucosal scrapings were pooled within the defined duodenal, jejunal and ileal segments for the same pig. Brush border membrane fractions were prepared from mucosal scrapings according to the method of Maenz and Patience (1992). The aliquots were stored at -70°C for further assays of enzyme activities. In addition, specimens from the middle part of jejunum segment were excised, flushed with physiological saline and fixed in 10% formalin. Three cross-sections for jejunal sample were prepared after staining with hematoxylin and eosin using standard paraffin embedding procedures (Xu et al., 2003). A total of 10 intact, well-oriented crypt-villus units were selected in triplicate for jejunal cross-section. Villus height and crypt depth were determined using image processing and analysis system (Version, Leica Imaging Systems Ltd., Cambridge, England).

Enzyme assay

Enzyme activities for disaccharidases (maltase, sucrase and lactase) were measured according to the procedure of Dahlqvist (1964). The homogenate was incubated with the substrate (lactose or sucrose), and the liberated glucose was measured by a glucose-specific hexokinase reaction. Alkaline phosphatase was assayed according to the method of Engstrom (1964). The homogenate was incubated with p-nitrophenyl phosphate at 38°C. Protein concentrations were determined according to the method of Bradford (1976). Enzyme activities were normalized to protein content. Total jejunal hydrolase activities (µmol hydrolyzed/min) over the entire jejunal segment were estimated as enzyme activity per unit of mucosal homogenate protein × homogenate protein content per gram mucosa × total jejunum mucosa weight (Zhang et al., 1977).

Statistical analyses

Statistical analyses were performed using the GLM procedures of SPSS 11.5. Individual pig was the experimental unit. Means were separated with Turkey procedure at a significance level of P<0.05 and all data are presented as mean ±S.E.M.

Results

Body weights and small intestinal morphometry

Body weights (BW), small intestinal weights, and length presented in Table 2 show the expected increase (P<0.05) from 35 to 125 d. There was an 8.26-fold increase in BW from 3.56 kg at 35 d to 32.97 kg at 125 d. Weight gains averaged 265 and 388 g/d from 35 to 80 d, and 80 to 125 d, respectively. Body weight gains were greater from 80 to 125 d than from 35 to 80 d (P<0.05). Total intestinal weights and intestinal mucosa weights increased more rapidly from 35 to 80 d than from 80 to 125 d. Small intestinal lengths decreased relative to gain as Jinhua gilts grew during the 35- to 125-d postnatal period. Small intestinal weight as a proportion of BW was greatest at 80 d for the age groups studied (P<0.05). Jejunal villus height of Jinhua gilts was the lowest at 35 days of age, significantly increased at 80 days of age (P<0.05), and remained a high level at 125 days of age. However, jejunal crypt depth was the highest at 35 days of age and significantly decreased at 80 and 125 days of age (P<0.05).

As shown in Table 3, weights of the duodenum, jejunum, and ileum increased as Jinhua gilts grew from 35 to 125 d (P<0.05). Weights of the mucosa in each section of the small intestine were greater at 125 d than at 35 or 80 d of age (P<0.05). The length of jejunum was greater in gilts at 125 d than at 80 d (P<0.05), which was greater than in those at 35 d of age (P<0.05). Between the ages of 35 to 125 d, the increase in mucosa weight was greatest for the jejunum.
Table 2.  Body weight and small intestine morphometrics of growing Jinhua gilts, fresh tissue basis.

| Item                        | Age, days |          |          |          |
|-----------------------------|-----------|----------|----------|----------|
|                             |           | 35       | 80       | 125      | SEM      |
| No. gilts                   |           | 6        | 6        | 6        |          |
| BW kg                       |           | 3.56c    | 15.50b   | 32.97a   | 2.96     |
| Intestinal weight g         |           | 170.61c  | 929.70b  | 1578.44a | 141.32   |
| Intestinal length m         |           | 7.23c    | 15.19b   | 18.46a   | 1.19     |
| Intestinal weight/BW g/kg   |           | 49.57h   | 60.11a   | 47.83b   | 1.81     |
| Mucosa weight g             |           | 137.29c  | 748.12b  | 1270.16a | 113.44   |
| Mucosa weight/intestinal weight g/kg | | 810.87 | 804.93 | 805.37 | 10.18 |
| Mucosa weight/BW cm/kg      |           | 39.88b   | 48.37a   | 38.49b   | 1.45     |
| Intestinal length/BW cm/kg  |           | 210.15a  | 98.18b   | 55.94c   | 16.49    |
| Jejunal Villus height µm    |           | 235.84b  | 320.93a  | 314.93a  | 12.55    |
| Jejunal Crypt depth µm      |           | 109.02a  | 74.11b   | 88.35b   | 6.04     |

Means in the same row that do not have common superscripts differ, P<0.05. SEM: Standard error of the mean.

Table 3.  Morphometrics of the small intestinal regions of growing Jinhua gilts, fresh tissue basis.

| Item                        | Age, days |          |          |          |
|-----------------------------|-----------|----------|----------|----------|
|                             |           | 35       | 80       | 125      | SEM      |
| No. gilts                   |           | 6        | 6        | 6        |          |
| Duodenum:                   |           |          |          |          |
| Weight g                    |           | 14.51c   | 79.06b   | 134.24a  | 12.02    |
| Mucosa weight µm            |           | 7.41c    | 64.34b   | 111.77a  | 10.46    |
| Length m                    |           | 0.81b    | 1.24a    | 1.35a    | 0.06     |
| Jejunum:                    |           |          |          |          |
| Weight g                    |           | 134.71c  | 734.06b  | 1246.38a | 111.58   |
| Mucosa weight µm            |           | 119.17c  | 597.75b  | 1009.77a | 89.43    |
| Length m                    |           | 5.56c    | 12.58b   | 15.51a   | 1.06     |
| Ileum:                      |           |          |          |          |
| Weight g                    |           | 21.39c   | 116.57b  | 197.91a  | 17.72    |
| Mucosa weight µm            |           | 10.71c   | 86.03b   | 148.61a  | 13.83    |
| Length m                    |           | 0.86c    | 1.37a    | 1.60a    | 0.08     |

Means in the same row that do not have common superscripts differ, P<0.05.
followed by the ileum and duodenum. The increase was greatest for the duodenum followed by the ileum when mucosal weight was expressed per unit of the appropriate intestinal segment weight, whereas jejunal mucosal weight decreased with age.

**Jejunal mucosa protein content and hydrolase activities**

Table 4 shows the jejunal mucosa protein content and hydrolase activities of the growing Jinhua gilts. Mucosal homogenate protein concentrations of the harvested jejunums did not differ among the age groups studied. There were variations in enzyme activities among Jinhua gilts of 35, 80, and 125 d of age. Maltase activity increased with age (P<0.05), and the rate of increase was similar between the period from 35 to 80 d and from 80 to 125 d. Sucrase activity did not differ between 35 and 80 days of age but was greater at 125 days of age (P<0.05). Lactase activity of Jinhua gilts decreased with age during growth, and was greater at 35 days of age (P<0.05). Both total jejunal maltase activity and total jejunal lactase activity expressed per unit of jejunal mucosa weight were greatest at 125 days of age.

| Table 4. Mucosal protein and hydrolase activities in jejunum of growing Jinhua gilts, fresh tissue basis. |
|----------------------------------------------------------|-------------------|-------------------|-------------------|-------------------|
| Age, days | 35 | 80 | 125 | SEM |
| No. gilts | 6 | 6 | 6 | |
| Protein/mucosa (mg/g) | 56.45 | 68.54 | 68.84 | 3.16 |
| Enzyme activity (nmol/mg protein.min): | | | | |
| Maltase | 93.05<sup>b</sup> | 113.80<sup>ab</sup> | 144.28<sup>a</sup> | 8.23 |
| Sucrase | 22.52<sup>b</sup> | 27.65<sup>b</sup> | 36.18<sup>a</sup> | 1.61 |
| Lactase | 20.36<sup>a</sup> | 15.96<sup>ab</sup> | 13.41<sup>b</sup> | 1.02 |
| Total jejunal activity (µmol/min): | | | | |
| Maltase | 587.02<sup>c</sup> | 4577.33<sup>b</sup> | 9835.30<sup>a</sup> | 935.68 |
| Sucrase | 147.96<sup>c</sup> | 1163.61<sup>b</sup> | 2511.05<sup>a</sup> | 238.64 |
| Lctase | 132.41<sup>c</sup> | 652.13<sup>b</sup> | 925.38<sup>a</sup> | 84.50 |
| Total activity per mucosa weight (µmol/min.g): | | | | |
| Maltase | 4.99<sup>c</sup> | 7.66<sup>b</sup> | 9.82<sup>a</sup> | 0.55 |
| Sucrase | 1.25<sup>c</sup> | 1.94<sup>b</sup> | 2.48<sup>a</sup> | 0.13 |
| Lactase | 1.13 | 1.09 | 0.92 | 0.05 |
| ALP activity: | | | | |
| ALP µmol/g protein.min | 48.73<sup>a</sup> | 37.54<sup>ab</sup> | 28.77<sup>b</sup> | 3.07 |
| Total ALP/mucosa mmol/min.g | 2.59<sup>a</sup> | 2.54<sup>a</sup> | 1.98<sup>b</sup> | 0.10 |
| Total ALP mmol/min | 308.36<sup>c</sup> | 1521.03<sup>b</sup> | 1995.13<sup>a</sup> | 182.74 |

<sup>a</sup>Means in the same row that do not have common superscripts differ, P<0.05.  
<sup>b</sup>ALP=alkaline phoshpatase.
age (P<0.05). Similarly, both total sucrase activity and total sucrase activity expressed per unit of jejunal mucosa weight in Jinhua gilts at 125 d were greater than that at 80 d (P<0.05), which was greater than that at 35 d of age (P<0.05). Total lactase activity increased with age, and was the greatest at 125 days of age (P<0.05). However, total lactase activity expressed per unit of jejunal mucosa weight did not differ among gilts of 35, 80, and 125 days of age.

Alkaline phosphatase activity was greater at 35 days of age (P<0.05). Total jejunal ALP in Jinhua gilts at 125 d was greater (P<0.05) than activity at 80 d, which was greater than that at 35 d of age (P<0.05). Total jejunal ALP activity expressed per unit of jejunal mucosa weight was lower at 125 d than at other ages (P<0.05).

**Discussion**

The increase in body weight, and the weight and length of the small intestine observed in this study is in agreement with previous results reported in the references (Ekstrom et al., 1975a; Lindemann et al., 1986; Jensen et al., 1997). In the present study, body weight increased linearly with age, however, in previous studies body weight increased exponentially or quadratically with age (Owsley et al., 1986; Jensen et al., 1997). This result confirms that Jinhua pigs have a lower growth rate compared with other commercial breeds (Landrace, Yorkshire etc.). The Jinhua gilt’s intestinal weight and length increased in direct proportion to its body weight. The results are in accordance with previous reports (Aodeola and King, 2006). Jensen et al. (1997) also reported that the weight of the small intestine and the length of the small intestine were described as a function of the body weight. In contrast, rat intestinal weight increased disproportionately rapidly (Tolza and Diamond, 1992) relative to body weight. In addition, associated with the increase in tissue weight was a significant increase in weight of the mucosa from 35 to 125 days of age. The result indicated that, from 35 to 125 days of age, the small intestine of Jinhua gilts undergoes a substantial increase in physical size to accommodate the processing of ingested nutrients. This result is similar to that reported by Adeola and King (2006), who observed that body weight, the weight and length of small intestine, as well as mucosa weight increase with age from 1 to 9 weeks. However, at the same age, Jinhua gilts have a lower weight and length of the small intestine compared with the breed previously reported (Jensen et al., 1997; Aodeola and King, 2006), which suggests that these differences may be attributed to the growth performance of different breeds. In addition, jejunal villus height increased with age; the result is in accordance with a previous report (Vente-Spreeuwenberg et al., 2004), which observed that small intestinal villus height of weaned piglets increased from 4 to 14 days post weaning. We find that Jinhua gilts have shorter villi compared with those in the previous report. These differences may be attributed to the slow development of small intestine in Jinhua pigs.

The developmental changes in weights among the duodenum, jejunum, and ileum were evident in mucosa weight. It has been reported that the duodenum, jejunum, and ileum represent 4 to 5%, 88 to 91%, and 4 to 5%, respectively, of the length of the small intestine in fully-grown pigs (Yen, 2001). Aodeola and King (2006) also reported that the duodenum accounts for approximately 10, 9 and 7% of the length of the small intestine in 3-, 5- and 9-week-old pigs, respectively. Corresponding numbers for the jejunum are approximately 78, 81, and 84% with values of 12, 10, and 9% for the ileum. In the current study, the duodenum,
jejunum, and ileum represented 11, 8, and 7%, and 77, 83, and 85%, and 12, 9, and 8%, respectively, of length of the small intestine in 35-, 80-, and 125-day-old Jinhua gilts. The results indicate that the jejunum represents more of the length of small intestine as the pig grows (Adeola and King, 2006).

Mammalian intestinal brush-border hydrolases, including alkaline phosphatase and disaccharidases, are responsible for the final stages of macronutrient digestion (Semenza, 1986). In the current study, we characterized developmental changes of enzyme activity in brush-border membrane of Jinhua gilts. Brush-border maltase and sucrase serve as the final step in small intestinal digestion of starch to glucose, and have a common ancestral gene with shared exon structures and peptide domains (Nichols et al., 2003). Therefore, sucrase digests all the sucrose and about 80% of dietary maltose, and maltase digests the remaining maltose (Swallow et al., 2001). The present data revealed that total and specific sucrase and maltase activities increase significantly with age, whereas, specific lactase activity decreases significantly with age, which perhaps reflects the switch in dietary carbohydrate from predominantly lactose to starch after weaning, because of substrate effects on enzyme production in the digestive tract (Adeola and King, 2006). The results of our study are in agreement with previously reported studies (Aumaitre and Corring, 1978; Kidder and Manners, 1980; Shulman et al., 1988), which observed that brush-border sucrase and maltase activity increased with age. Specific activity of lactase reached a maximum at the end of the 1st week after birth and decreased afterwards (Aumaitre and Corring, 1978). Ekstrom et al. (1975b) reported that the mean of specific lactase activity was highest at 1 and 8 days of age and then fell progressively to a minimal level at 43 days of age. These enzymatic changes coincide with the transition from the milk-based diet, in which the primary carbohydrate is lactose, to the diet of solid foods (Büller and Grand, 1990). This result is similar to those reported for ducks (King et al., 2000) and rats (Raul et al., 1988). During growth between 35 to 125 d in the current study, sucrase and maltase activity of Jinhua gilts increased 0.64- and 0.55-fold, respectively. Lactase activity decreased 0.34-fold. The result was lower compared with previous reports. Growth performance of different breeds could result in the differences. Increased enzymes activities in growing Jinhua gilts that we observed could result in increased digestion and absorption of intraluminal nutrients. Our previous study also confirmed that the intestinal amylase activity increases with age (data not shown).

Alkaline phosphatase is localized mainly in the brush border area on the external side of the microvilli (Welsh et al., 1985). It is an important constituent of the microvillus membrane, and often used as a marker of enterocyte differentiation (Ashkenazi et al., 1984; Hinnebusch et al., 2002). In the current study, there was a significant age-related developmental change in jejunal brush-border ALP activity of Jinhua gilts among the age groups. During growth from 35 to 125 days of age in the current study, ALP activity of Jinhua gilts decreased 0.41-fold. The result is similar to those reported for rats (Holt et al., 1991) but different from the reports of Adeola and King (2006), who observed that ALP activity did not differ during growth between 1 to 9 weeks. The growth rate of different breeds could result in the differences. Fan et al. (2002) also observed that ALP decreased with age after weaning, which was highest in the weaning (28-day-old) and lowest in the adult (70-day-old).

Disaccharidases and alkaline phosphatase are important constituents of the microvillus membrane and changes in their
activities could result in changed absorption of nutrients. In the current study, these enzymatic changes, accompanied by profound modifications of intestinal morphology and transport functions, coincide with the transition from a milk-based diet, in which the primary carbohydrate is lactose, to a diet consisting of solid foods. Our results confirm the reciprocal switch in the intestinal activities of lactase and sucrase. In the current study, relative intestinal weight and mucosa weight in Jinhua gilts were significantly greater at 125d than at 35 d of age, meanwhile, specific jejunal sucrase and maltase activities increased with age from 35 to 125 days of age. However, lactase and ALP activities decreased with age during growth. The results suggest that whole body growth rate is determined in part by the allocation of tissue to the gastrointestinal tract (Obst and Diamond, 1992), and age-related increase in intestinal brush-border enzymes support developmental change in hydrolytic capacity and that amplified intestinal growth is observed in growing pigs (Adeola and King, 2006).

Conclusions

Age is an important factor that influences the brush-border enzyme activity. Analyzed jejunal enzymes (maltase and sucrase) showed a marked increase in their activity. However, lactase and ALP activities displayed a decrease in their activity, in a strong correlation with age. The age-related increase in the studied enzymes in growing Jinhua gilts could be associated with increased nutrient absorption. Increases in body weight during growth (from 35 to 125 days of age) are accompanied by significant developmental changes in digestive capacity including intestinal weights, length as well as jejunal brush-border sucrase, maltase, lactase and ALP activities.

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