

Comparative characteristic of gastrointestinal tract development and digestibility of nutrients in young chickens, ducks and geese

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Abstract

The rate of development of digestive tract and its functions in different poultry species, with special attention given to ducks and geese were investigated. These works were being realised simultaneously in the same environmental conditions and with birds at the same age. Significant inter-species differences in the rate of digestive tracts development, in digestibility of amino acids and structural substances as well as in fermentation of NSP polysaccharides and its consequences in energy utilisation indicate that the faster development and reaching of digestive maturity, especially in the case of amino acids, was observed in chickens. In waterfowl the tendency of better both digestibility of structural carbohydrates and energy utilisation from NSP was stated.

Keywords: digestive tract, development, chickens, ducks, geese

Introduction

The posthatching growth and development of different birds, including domestic poultry as well, have been investigated by many authors (Dror et al.,1977; Nitsan et al.,1991; 1995; Chamblee et al.,1992; Nir et al.,1993; Palo et al.,1995; Hai et al.,1996). Many studies focused on the allometric development of gastrointestinal tract (GIT) which is an important factor that limits the possibilities of feed intake and, in consequence, negatively affects the growth intensity and performance resulting from the genetic potential of poultry. The implications of early and fast development of inner organs and tissues, synthesis and secretion of digestive enzymes to a great extent determine the further conversion and utilization of nutrients (Huhtanen a. Pensack.,1965; Thornburn a. Willcox,1965; Clemens et al.,1975; Jamroz a. Bieliński,1975; Gasaway,1976; Escribano et al., 1988; Krogdahl a. Sell,1989; Sell et al.,1991; Bolton a. Dewar,1965; Noy a. Sklan,1995; Hsu et al.,1996; Sklan, 2001; Uni, 2003).

Information on the early nutrition and development of GIT, that were published in many works were related mainly to the chicken of meat or laying type and to turkey. The data regarding waterfowl or comparison of different bird species are sparse (Brüggemann,1931; Mattlocks,1971; Björnhag a. Sperber,1977; Lilja,1983; Applegate et al.,2005).

Size of gastrointestinal tract, digestibility, NSP fermentation in different poultry species

Many aspects of poultry nutrition are interpreted as data concerning all species without clear accentuation of specific differences resulting from species, time of day and age (Savory a. Knox,1991). As an example of the importance of composition of diet and age the data concerning the measurements made in young White Italian geese could be given. The dynamic of growth rate of small and large intestine to a great extent resulted from kind of basal grain and concentration of polysaccharides in the feed mixtures (Jamroz et al.,1991,1992,1994; Wiliczekiewicz et al.,1992; Yu et al.,1998). Similar growth rate of size of small and large intestine segments were noted between 5, 8 and 11 weeks of life. On the other hand, it is easy to see that the caecum length related to the body weight (BW) was already similar in 8- and 11- weeks old geese in comparison to the measurements made in 5-week old birds (Table 1).

Table 1. Length of intestine in geese depending on age (Wiliczekiewicz et al.,1989)

Parameters	Age in weeks					
	5		8		11	
Segments of intestine	cm	%	cm	%	cm	%

- small (cm/kg BW)	80.0A	100.0	54.1B	67.6	46.9C	58.0
- large (cm/kg BW)	6.9A	100.0	4.5B	65.2	3.7C	54.6
- caecums (cm/kg BW)	22.4A	100.0	14.2B	63.4	13.8B	61.6

The values in the same rows marked with A,B differ significantly at P<0.01

Results of investigations performed simultaneously with three species at the same age that were reared in the same conditions and feeding regime indicate numerous, important differences. The intestine expressed in the cm/kg of birds' BW at 6-8 weeks of life was significantly shorter in geese (92.4) in comparison to chickens and ducks (133 or 124 cm/kg BW), the weight of visceral organs – liver and pancreas and gizzard was significantly greater in waterfowl (Table 2). The retention of nitrogen and phosphorus was in these birds very similar and varied within 44-48 and 17.5-17.8 %, respectively (Jamroz et al.,1996b). The digestibility of structural substances of cell walls was significantly better in chickens and geese than in ducks (Table 2). Greater amounts of short chain fatty acids (SCFA) were found in the contents of small and large intestine of 8-10 weeks old geese and ducks as compared to chickens, however in caecum the higher concentrations of SCFA (186.7 mmol/kg) were determined in ducks and chickens (144.3 and 151.3 mmol/kg) (Jamroz et al.,1996a). More SCFA were estimated in ducks's intestine than in chickens in other experiment of Jamroz et al. (1994).

Table 2. Allometric parameters of gastrointestinal tracts and N and P utilization in 6-8 weeks old birds (means for two experiments and three diets (means; ±SD) (Jamroz et al.,1996b)

Parameters	Chickens (Hybro N)		Ducks (Astra K-2)		Geese (WD)	
Length of intestine (cm/kg BW)						
- Small intestine	105.1a	±38.9	101.1a	±25.1	70.3b	±17.7
- Rectum	5.6	±2.2	6.5	±1.5	4.8	±1.4
- Caecum	22.7	±6.4	16.2	±4.8	16.2	±4.6
Total intestine	133.4a	±47.2	123.8a	±31.0	92.4b	±23.3
Weight (g/kg BW)						
- Gizzard	17.16a	±4.2	32.3b	±5.7	38.9b	±8.7
- Liver	25.1	±5.5	28.6	±8.0	31.3	±8.2
- Pancreas	2.7	±0.7	5.6	±1.0	3.8	±1.2
- Abdominal fat	13.1	±7.5	8.1	±5.6	17.6	±5.4
N-retention (in % of N intake)	45.3		48.2		44.0	
P-retention (in % of P intake)	17.6		17.5		17.8	

The values in the same rows marked with a,b differ significantly at P<0.05

Table 3. Apparent fecal digestibility of structural substances in poultry at age of 6 and 8 weeks (in %) (Jamroz et al.,1996a) (means, ±SD)

Parameters	Chickens (Hybro N)		Ducks (Astra K-2)		Geese (WD)	
NDF	25.7Aa	±9.6	18.1Bb	±8.6	23.2a	±8.6
ADF	3.3	±6.8	2.8	±10.0	5.9	±9.4
Hemicellulose	39.9Aa	±13.4	27.8Bb	±12.4	34.1ab	±12.9

Each estimation for 12 animals

The values in the same rows marked with a,b differ significantly at P<0.05; with A,B differ significantly at P<0.01

Higher values, 44-56 for N- and 47-57 % for P-retention, were registered in our earlier experiments (Wiliczekiewicz et al.,1995; Jamroz et al.,1998b). Very important for digestion of structural substances is the population of microflora in the intestine content (Barnes et al.,1972; Savage,1977; Jamroz,1998a,b,c). Particularly clear differences were determined in total number of microorganisms in chicken, ducks or geese fed diets containing Triticale as a basal grain. The average number of microorganisms in analysed segments of intestine (small, large and caecum) of young birds (at age of 28 and 32 days) reached in geese 9.1; 9.2 and 9.5; in ducks 8.5; 8.6 and 8.8 and in chickens 5.3; 8.8 and 9.2 CFU/g (log₁₀), respectively (Jamroz et al.1998a). In this experiment the highest NSP-saccharides digestibility coefficients were obtained in ducks and geese in comparison to chickens (Table 4). Depending on diets given, the highest availability of NSP-energy was obtained in ducks and geese (8.57), significantly lower values were estimated for chickens (7.79 MJ/kg NSP) (Jamroz et al.,1998c; Kirchgessner et al.,1999) (Table 5), although the degree of SCFA absorption from intestine lumen is still not well known (Lebars et al.,1963; Sudo a. Duke,1980).

Significantly higher (P<0.01) activity of serum and pancreatic alpha amylase and lipase was determined in ducks as compared to other examined birds (Table 6).

Table 4. Apparent fecal digestibility of NSP-saccharides in different poultry species (in % means for three diets) (Jamroz et al.,1998c) (means; ±SD)

	Chickens (Messa 243)		Ducks (Barbarie)		Geese (Landaise)	
Fucose	67.4A	±10.2	78.4B	±8.4	71.7A	±10.7
Arabinose	56.7a	±11.3	62.6b	±6.9	60.5ab	±10.2
Xylose	34.2	±15.1	40.5	±16.1	39.2	±15.9
Mannose	64.4a	±12.0	67.6ab	±11.3	71.4b	±11.3
Glucose	76.2A	±8.0	80.6B	±4.4	80.7B	±6.7
Galactose	59.8A	±12.9	73.3B	±8.9	71.9B	±12.2
Total NSP	54.8a	±9.5	60.9b	±8.1	59.8b	±9.9

The values in the same rows marked with a,b differ significantly at P<0.05; with A,B differ significantly at P<0.01

Table 5. Available energy (MJ/kg) from NSP-sugars determined on basis of SCFA production in three poultry species (Kirchgessner et al.,1999)

	Chickens		Ducks		Geese	
Acetic acid	3.75a	±0.72	4.31b	±0.58	4.12b	±0.69
Propionic acid	1.54a	±0.30	1.79b	±0.24	1.76b	±0.29
Butyric acid	2.50a	±0.48	2.52a	±0.34	2.62b	±0.44
Total	7.79a	±1.40	8.63b	±1.12	8.51b	±1.41

The values in the same rows marked with a,b differ significantly at P<0.05

Table 6. Enzyme activity in blood serum and pancreas of chickens, ducks and geese at 42 days of age (means, ± SD) (Jamroz et al.,2001)

	Chickens (Shaver/Starbro)		Ducks (Mulard)		Geese (Landaise)	
Serum, U/ml						
α-Amylase	808A	±277	7816B	±961	8178B	±958
Lipase	20A	±6.3	41B	±8.4	12C	±2.9
Pancreas, U/mg protein						
α-Amylase	18A	±3.6	25A	±3.9	13B	±3.0
Lipase	0.92a	±0.21	1.78b	±0.38	1.96b	±0.42

Each estimation for 12 animals

The values in the same rows marked with a,b differ significantly at P<0.05; with A,B significantly at P<0.01

Numerous differences in the size of GIT stated between domestical poultry species caused that the further studies were undertaken. The diets with 40 % of barley containing on average 138 g of total NSP, 34 g of soluble NSP, 17 g of β -glucan and 161 g dietary fibre per kg were applied (Jamroz et al.,2001). In 21-day-old birds the longest gut segments was stated in chickens, similarly as in earlier experiment, organ weights were highest in ducks, while in birds at age of 42 days the significantly better developed caeca and colon were observed in geese. All GIT-organs related to $BW^{0,67}$ were bigger in waterfowl than in chickens (Table 7).

Table 7. Length of gut segments and weight of organs in chickens, ducks and geese expressed in relation to metabolic $BW^{0,67}$ (means, \pm SD) (Jamroz et al.,2001)

	Chickens (Shaver/Starbro)		Ducks (Mulard)		Geese (Landaise)	
<i>At age of 21 days</i>	Length, cm/kg $BW^{0,67}$					
Small intestine	210A	\pm 23	151B	\pm 15	156B	\pm 12
Caeca	42A	\pm 3.7	27B	\pm 3.4	37C	\pm 5.1
Colon	9.8	\pm 1.4	9.5	\pm 1.4	10.1	\pm 1.4
Total	262A	\pm 26	188B	\pm 18	202AB	\pm 14
	Organ weight, g/kg $BW^{0,67}$					
Proventricle	6.3A	\pm 1.1	8.0B	\pm 1.3	6.7 A	\pm 1.4
Gizzard	26A	\pm 3.6	40B	\pm 4.0	59C	\pm 6.8
Pancreas	3.6A	\pm 0.7	5.2B	\pm 1.0	6.7C	\pm 1.0
Liver	31A	\pm 3.3	35A	\pm 5.6	65B	\pm 10
<i>At age of 42 days</i>	Length, cm/ kg $BW^{0,67}$					
Small intestine	106A	\pm 8.5	104A	\pm 7.3	97B	\pm 7.5
Caeca	23A	\pm 2.7	18B	\pm 1.8	26C	\pm 2.4
Colon	5.3A	\pm 0.8	6.5B	\pm 1.1	7.8C	\pm 1.0
Total	134	\pm 10	130	\pm 8.8	131	\pm 8.1
	Organ weight, g/kg $BW^{0,67}$					
Proventricle	5.4A	\pm 1.2	7.4B	\pm 1.8	7.6B	\pm 2.0
Gizzard	22A	\pm 3.0	41B	\pm 3.4	53C	\pm 5.7
Pancreas	2.9A	\pm 0.5	4.6B	\pm 0.8	4.8B	\pm 0.8
Liver	34A	\pm 3.4	41B	\pm 5.3	48C	\pm 5.9

Each estimation for 12 animals; The values in the same rows marked with A,B differ significantly at $P<0.01$

The estimated apparent digestibility of nutrients was significantly ($P<0.01$) greater in ducks and chickens, crude fat was better digested in ducks, but structural substances (NDF, ADF, hemicellulose) in chickens (Jamroz et al., 2001). Apparent ileal digestibility of numerous aminoacids was significantly higher in chickens than in other birds ($P<0.01$) (Table 8).

Table 8. Apparent digestibility of nutrients and selected aminoacids on 42 day of age (means, \pm SD) (for 10 cages per species¹⁾) (Jamroz et al.,2001)

Item	Chickens (Shaver/Starbro)		Ducks (Mulard)		Geese (Landaise)	
Starch	95.7A	\pm 1.3	98.1B	\pm 0.7	98.3B	\pm 1.4
Crude fat	85.2	\pm 3.7	87.4	\pm 2.2	84.4	\pm 3.5
NDF ²⁾	35.4A	\pm 3.6	25.8B	\pm 4.3	22.5B	\pm 7.2
ADF ³⁾	1.9A	\pm 4.4	-8.9B	\pm 4.3	-20.6C	\pm 11.6
Hemicellulose	50.0A	\pm 3.6	41.0B	\pm 4.7	41.4B	\pm 5.5
Ileu	74.8A	\pm 8.4	66.4AB	\pm 10.0	52.4B	\pm 11.1
Leu	70.1A	\pm 8.7	58.1B	\pm 8.9	51.8B	\pm 11.4
Lys	71.7Aa	\pm 12.0	56.6ABb	\pm 11.6	40.8B	\pm 14.1

Met	69.5Aa	±14.5	43.8B	±16.9	51.6ABb	±12.2
Phe	76.8A	±7.3	71.3A	±6.3	54.6B	±9.7
Thre	61.6A	±11.9	48.7B	±10.2	49.6B	±14.5
Glu	85.2A	±5.1	81.8AB	±3.1	76.0B	±9.1
Tyr	67.0A	±10.4	72.5A	±7.4	29.5B	±17.4
Total amino acids	76.1A	±7.6	68.6AB	±6.0	56.0B	±10.1

The values in the same rows marked with a,b differ significantly at P<0.05; with A,B significantly at P<0.01

¹)Totally consist of 38 chickens, 28 ducks or 18 geese; ²)Neutral detergent fibre; ³)Acid detergent fibre.

Dynamic of growth of enzymatic activity of pancreas was diverse in examined species. The stable activity of alpha-amylase at the period of 1-28 days was stated in chickens but it was increased on day 42. In waterfowl activity of this enzyme was very low during first 7 days of life, but the increase of enzyme activity was faster and began from about 28 day of life. In contrast to the slow increase of lipase activity in chickens, in waterfowl higher activity was registered just on 28 day (Table 9). Estimated enzymatic activity of intestine walls shown on a great variability and no clear and insignificant tendency of changes was observed (Table 10).

Table 9. Enzymatic activity (u/mg of pancreas protein) (means, ±SD) (Jamroz et al.,2002b)

Days of life	Chickens (Shaver Starbro)				Ducks (Mulard)				Geese (Landaise)			
	α-Amylase		Lipase		α-Amylase		Lipase		α-Amylase		Lipase	
1	25A	±13	1.15A	±0.29	34A	±13	4.71B	±3.19	4.3B	±2.9	4.58B	±3.01
3	31A	±15	2.06	±0.77	17B	±4	2.70	±1.24	7.4C	±4.2	2.74	±1.46
5	34A	±15	2.84	±2.12	17B	±4	2.30	±0.72	7.5C	±4.4	2.19	±1.25
7	34A	±11	2.10	±1.01	14B	±4	2.41	±0.45	5.5C	±2.2	1.87	±1.00
28	36A	±16	3.76A	±1.93	117B	±27	14.81B	±4.51	55.9A	±28.1	19.63C	±5.08
42	43A	±24	6.78A	±3.06	158B	±68	16.55B	±5.16	184.5B	±86.3	23.05C	±8.25

Each estimation for 12 animals; The values in the same rows marked with A,B differ significantly at P<0.01

Table 10. Enzymatic activity in intestinal wall (u/g of wall-protein) (means, ±SD) (Jamroz et al.,2002b)

Days of life	Intestine part	α-Amylase	Lipase	Saccharase	Maltase
Chicken					
5	Duodenum	45.9 ±17.6	27.0 ±5.6	0.54 ±0.36	3.75 ±2.47
	Small intestine *	47.1 ±13.7	27.3 ±4.9	0.82 ±0.12	5.36 ±1.76
42	Duodenum	95.1 ±52.0	14.1 ±5.2	0.60 ±0.28	4.98 ±1.13
	Small intestine *	75.7 ±65.3	10.8 ±5.1	0.65 ±0.35	4.94 ±1.56
Ducks					
5	Duodenum	39.0 ±20.0	37.5 ±21.0	0.56 ±0.08	10.62 ±1.99
	Small intestine *	72.9 ±31.4	37.4 ±41.0	0.83 ±0.31	15.96 ±5.90
42	Duodenum	36.3 ±30.0	38.0 ±10.0	0.25 ±0.09	6.54 ±1.80
	Small intestine *	32.3 ±19.9	39.0 ±12.8	0.29 ±0.11	7.34 ±1.71
Geese					
5	Duodenum	18.7 ±6.4	27.0 ±13.6	1.24 ±0.31	8.30 ±1.27
	Small intestine	38.4 ±18.0	20.2 ±14.6	1.80 ±0.69	11.80 ±2.79
42	Duodenum	31.1 ±13.5	13.6 ±2.9	0.72 ±0.20	4.28 ±2.54
	Small intestine *	75.1 ±41.7	37.8 ±29.7	1.25 ±0.72	9.20 ±4.54

* small intestine from Meckel' diverticulum to conjunction of caeca and colon

By feeding of the birds with barley-rich diets high amount of products of fermentation in caecum was found, although only in geese the age of birds caused the significant differences

(Table 11). Simultaneously to the increased age decreased the share of acetic acid in total SCFA. For other fatty acids so clear changes were not observed.

Table 11. Concentration of the short chain fatty acids in caecum content (mmol/kg) and their share (mol %) in total amount of SCFA (means, \pm SD) * (Jamroz et al.,2002b)

Species	Chickens (Shaver Starbro)			Ducks (Mulard)			Geese (Landaise)		
	14	28	42	14	28	42	14	28	42
Total amount	250.2 \pm 32.0	269.3 \pm 49.0	247.7 \pm 58.3	232.2 \pm 42.6	208.8 \pm 43.5	211.7 \pm 57.7	239.9ab \pm 31.8	313.9a \pm 122.6	148.2b \pm 42.3
Share of SCFA (mol %)									
Acetic acid	74.9A \pm 1.8	66.3B \pm 3.7	56.7C \pm 1.8	68.5A \pm 1.6	66.9A \pm 1.6	59.7B \pm 1.7	70.0 \pm 0.4	63.9 \pm 3.6	67.1 \pm 7.4
Propionic acid	6.8 \pm 1.1	10.8 \pm 2.7	9.0 \pm 3.3	11.6ab \pm 0.3	13.3a \pm 2.5	8.6b \pm 1.6	7.4 \pm 0.2	8.7 \pm 1.3	9.6 \pm 2.2
Iso-butyric acid	0.2a \pm 0.1	0.6b \pm 0.1	0.5b \pm 0.2	0.3 \pm 0.0	0.4 \pm 0.2	0.4 \pm 0.1	0.2 \pm 0.0	0.3 \pm 0.1	0.4 \pm 0.2
Butyric acid	16.0A \pm 2.6	19.5A \pm 3.3	28.9B \pm 2.7	17.0A \pm 1.8	16.8A \pm 3.2	29.0B \pm 2.6	20.7 \pm 0.2	25.0 \pm 4.5	20.2 \pm 6.4
Iso-valerianic acid	1.0A \pm 0.1	1.2A \pm 0.2	1.9B \pm 0.5	1.1 \pm 0.1	1.0 \pm 0.2	1.0 \pm 0.3	0.7 \pm 0.2	0.9 \pm 0.2	1.2 \pm 0.5
Valerianic acid	1.1A \pm 0.1	1.6A \pm 0.3	2.9B \pm 0.8	1.5 \pm 0.0	1.6 \pm 0.4	1.3 \pm 0.3	1.0 \pm 0.2	1.2 \pm 0.4	1.5 \pm 0.3

Each estimation for 12 animals

The values for species in the same rows marked with a,b differ significantly at $P<0.05$; with A,B differ significantly at $P<0.01$

On the basis of the great differences obtained in apparent ileal digestibility of amino acids in birds could be stated that the digestive maturity of GIT in chickens was significantly greater than in geese, very young ducks (14 d) digested amino acids to a small extent only (Table 12).

Table 12. Apparent ileal digestibility of important amino acids (%) (means, \pm SD) (Jamroz et al.,2002b)

Species	Chickens (Shaver Starbro)			Ducks (Mulard)			Geese (Landaise)		
	14	28	42	14	28	42	14	28	42
Days of life									

Ileu	68.2 ±4.3	64.7 ±4.8	64.4 ±7.8	35.1a ±5.9	51.9b ±4.6	43.7ab ±13.0	56.5 ±2.3	54.0 ±8.1	52.0 ±6.8
Leu	63.6A ±4.0	73.2B ±2.9	71.9B ±5.1	41.7A ±3.0	63.9B ±1.8	60.1B ±8.8	62.1 ±2.8	60.8 ±5.9	62.7 ±5.7
Lys	63.9 ±4.8	65.1 ±6.8	61.7 ±9.3	14.7A ±6.4	45.5B ±3.1	41.2B ±19.0	44.3 ±4.1	46.3 ±10.3	40.5 ±8.9
Met	81.5a ±3.8	81.6a ±4.4	73.8b ±6.5	47.8A ±8.2	68.8Ba ±3.3	54.9b ±10.8	68.3 ±4.4	62.8 ±9.2	60.4 ±4.8
Thr	62.0 ±5.1	55.3 ±5.7	59.1 ±8.0	17.7A ±10.7	39.7B ±5.3	35.6B ±13.3	45.1 ±3.0	45.8 ±9.2	41.6 ±8.2
Tyr	48.8A ±6.1	74.5B ±6.9	73.6B ±5.7	21.3A ±6.2	63.1B ±4.6	57.4B ±9.6	50.4a ±5.6	62.6b ±8.1	62.3b ±5.6
Try	65.3A ±3.1	72.2B ±3.2	73.1B ±4.3	30.1A ±7.8	52.9B ±4.2	56.1B ±9.4	59.0a ±3.1	64.3ab ±5.6	69.4b ±8.8
Total AS	69.7 ±3.5	73.0 ±4.1	72.5 ±5.0	43.8a ±3.3	61.8b ±1.9	59.8b ±8.9	63.6 ±2.1	62.7 ±6.2	62.8 ±5.2

The values for species in the same rows with a,b differ significantly <0.05; with A,B differ significantly P<0.01

Similar as in earlier conducted experiment, in which triticale was used as a basic grain, in birds fed barley-diets, the availability of energy of SCFA created from NSP was high in ducks, lower in geese and chickens, but for total SCFA-energy from NSP the differences between species were insignificant. These values were even two times lower than obtained when triticale was used.

Table 13. Available energy (MJ/kg) from NSP-sugars determined on basis of SCFA production (means, ± SD) for 12 animals per species (Jamroz et al., 2002a)

	Chickens (Shaver/Starbro)		Ducks (Mulard)		Geese (Landaise)	
Acetic acid	1.28a	±0.41	1.74b	±0.59	1.41ab	±0.21
Propionic acid	0.30a	±0.10	0.43ab	±0.16	0.45b	±0.13
Iso- and butyric acid	1.10a	±0.31	0.89ab	±0.24	0.72b	±0.13
Iso- and valeric acid	0.15a	±0.03	0.10b	±0.05	0.14a	±0.05
Total	2.83	±0.73	3.16	±0.96	2.73	±0.40

The values in the same rows marked with a,b differ significantly at P<0.05; with A,B significantly at P<0.01

The dynamic of energy retention rate in birds show on increase with age in chickens and ducks. In geese the significant changes were not related to age (Table 14).

Table 14. Energy retention in poultry depending on age (means, ± SD) (Jamroz et al., 2004)

Species	Chickens			Ducks			Geese		
	15-21	29-35	42-44	15-21	29-35	42-44	15-21	29-35	42-44
Energy retention to intake (%)	60.2a ±1.7	61.4ab ±2.4	64.5b ±4.9	66.7A ±2.1	67.1A ±2.0	70.1B ±2.6	72.9A ±1.6	66.7B ±3.9	71.3A ±3.0

The values for species in the same rows marked with a,b differ significantly at P<0.05; with A,B differ significantly at P<0.01

The differences between other recorded indices estimated in three poultry species at the same age and kept under the same conditions appeared to be very interesting. The studies on the rate of yolk sac resorption in chickens, ducks and geese show that the deepest resorption of

nutrient residues from yolk sac was stated in chickens and this process was slower than in waterfowl (Jamroz et al.,2004). On day 7 almost 30 % of chickens had a unabsorbed yolk sac (Table 15). The development of small intestine and caeca was better and quicker in chickens, but the large intestine - in ducks. Pancreas and liver growth was significantly greater in waterfowl (Fig. 1). In this study all birds were fed with similar diets containing combination of barley, wheat and maize grain.

Table 16. Protein and ether extract content of yolk sac (g per 100 g of fresh yolk sac content) (means, \pm SD) (Jamroz et al., 2004)

Days	Protein (N x 6.25)			Ether extract (fat)		
	Chickens	Ducks	Geese	Chickens	Ducks	Geese
1	26.0A \pm 3.20	17.4B \pm 4.61	17.8B \pm 2.85	14.6A \pm 3.11	25.3B \pm 9.50	23.4B \pm 4.47
3	15.1a \pm 6.94	9.1b \pm 1.35	15.3a \pm 4.94	18.7a \pm 9.40	31.6b \pm 11.35	20.8a \pm 3.29
5	9.4 \pm 1.95	11.3 \pm 6.38	14.3 \pm 1.83	17.0a \pm 3.10	22.8b \pm 1.74	12.9a \pm 5.47
7	11.8* -	- -	20.9* -	13.4 \pm 12.23	- -	7.4* -

* single yolk sac

The values for species in the same rows marked with a,b differ significantly at $P<0.05$; with A,B significantly at $P<0.01$

Conclusion

Analysis of the presented results will demonstrate great differences in the rate of development of gastrointestinal tracts, organs and digestive functions in three different poultry species. It should be noted that all data were obtained from the birds at the same age, fed the same diets and reared in the same environmental conditions.

The absolute values obtained for the length of intestine were significantly higher in waterfowl, but the same values calculated to body weight were highest in chickens, while the organ weights were greater in geese and ducks. The resorption of yolk sac residues was faster and deeper in waterfowl than in chicken. The increase of enzymatic activity was harmonious in chickens, in waterfowl – low, but from about 28 day of life it dynamically grew up. The pancreatic and intestinal amylase activity was higher in chicken but lipase activity was higher in ducks and geese.

Digestibility of many amino acids was significantly higher in chickens than in ducks and geese, however totally lowestmost digestibility coefficients were registered in ducks.

The ability for digesting of structural substances was different in young birds. In the performed studies the NDF and hemicelluloses were significantly better digested in the chickens than in ducks and geese.

Some residuals of NSP-saccharides were better digested in waterfowl, thus in consequence of it, different amounts of short chain fatty acids were created in the intestine content. In the majority of works the slightly higher concentration of SCFA was found in the intestine of ducks and geese. In total, because of lower digestibility of structural substances the greater SCFA amounts were obtained. Depending on the diets given and amount of synthesized SCFA and share of acetic, propionic and butyric acid in total SCFA quantity the available energy from NSP (calculated for triticale diets) amounted 7.8 KJ/g NSP in chickens and in ducks and geese this value reached 8.5-8.6 KJ/g NSP and calculated for barley diets these values were as 2.8; 3.2 and 2.7 KJ/g NSP, respectively.

From numerous results the careful conclusion can be formulated that chickens reach the maturity of digestive function faster than ducks or geese at the same age, what can have the important consequences for feeding of very young birds of different species.

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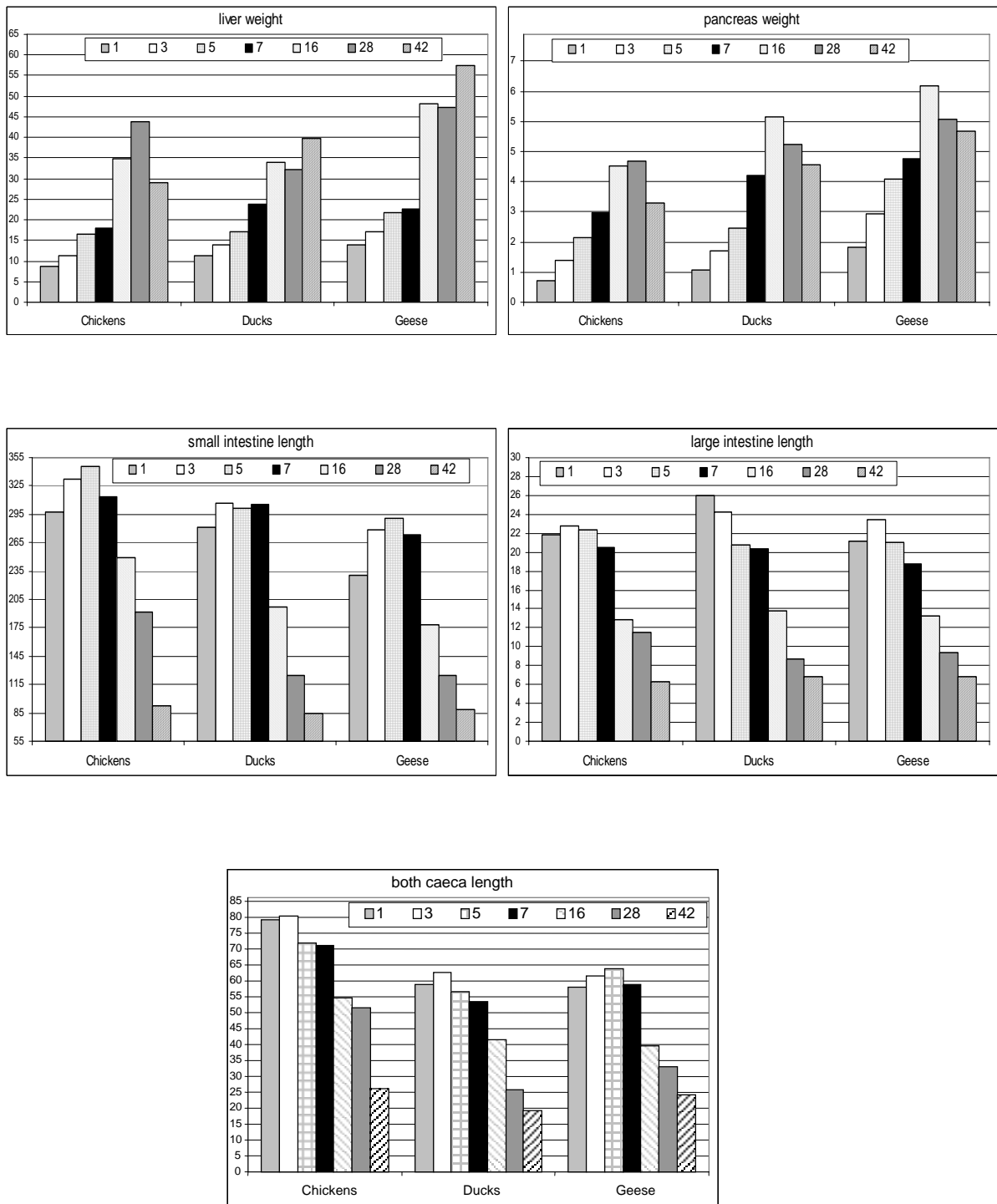


Fig. 1. Dynamic of some organs weight gain (g/100g BW^{0.67}) and length of intestine segments (cm/100g BW^{0.67})