High-test molasses or maize as an energy source for growing pigs. Status of digestive organs

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To study the status of digestive organs, sixteen pigs of commercial crossbreed, females and castrated males, in the same proportion, were used, of about 55 kg of live weight, randomly divided into two groups. The animals after 30 kg were fed *ad libitum*, with diets of high-test molasses or maize, as only energy source, and torula yeast, as only protein source. There were no main effects of the interaction sex per diet, neither sex effect. The digestive tract was numerically lower and the large intestine was significantly less heavy (P< 0.05) in the treatment with high-test molasses (43.0 and 16.3g/kg of body weight), in contrast with the maize (46.6 and 20.0g/kg of body weight). Equally, in the high-test molasses diet, the percentage contribution was significantly (P< 0.05) lower (37.9%) than in the maize diet (43.0%). In pigs fed with high-test molasses/torula yeast, the liver weighed more (P>0.01) and the pancreas less (P< 0.001) than those fed with maize/torula yeast. It is suggested that there are differences in the gastrointestinal macro-architecture and accessory glands of the pigs in growth, fed with diets of high-test molasses, as only energy source.

Key words: *pigs, high-test molasses, gastrointestinal tract, morphometry*

Many *sui generis* pig cattle rearing systems have been designed in Cuba, in which the energy and protein sources are tropical and no conventional. These systems are also locally available (Pérez 1997). Among these food resources are the high-test molasses of sugar cane and the torula yeast. Due to lack of information related to this way of feeding and rearing pigs, researches that contribute to understand the *modus operandi* of these food systems are needed, including the digestive processes that take place within the animals (Ly 1996, 2008).

There are references of morphological studies of the gastrointestinal tract (GIT) of pigs fed with different sugar cane molasses, after weaning (Díaz and Ly 1997 and Páez *et al.* 1998), and at the end of fattening (Ly and Mollineda 1983 and Xandé 2008). Nevertheless, there is little information related to the gastrointestinal macro-architecture of animals fed with yeast (Figueredo *et al.* 1981). It is known that yeasts constitute a protein source available in Cuba (Lezcano 1996 and 2005). Nevertheless, there are no experimental evidences of anatomic measures from the end of growth stage and beginning of fattening, in pigs raised with high-test molasses and torula yeast. The objective of this evaluation was to study the gastrointestinal morphometry of pigs fed with high-test molasses or maize, as the only energy source during the growth stage, which, in Cuba, it is defined between the 30 and 60 kg of body weight.

Materials and Methods

A total of sixteen Yorkshire x Landrace x Duroc pigs, females and castrated males, in the same proportion, around 55 kg of liveweight were divided randomly into two groups, in accordance with a 2 x 2 factorial arrangement. The factors were sex, females and castrated males, and the maize or high-test molasses diet. Animals of 30 kg or more were fed *ad libitum*, with diets of high-test molasses or maize, as the only energy source with 65.5 and 79.3%, respectively. In a research carried out by Ly *et al.* (2013), the details of the experimental diets and some aspects of lodging and manipulation of the animals were informed.

After six weeks of started the study, pigs were weighed before the slaughter. The procedures of extraction of the digestive organs have been described in a research of Ly (1975). In the case of large intestine, the colon was divided into near colon and distant colon. It bonded and cut in the coli flexure (Ly and Mollineda 1984). The mesentery was taken from the digestive organs and then, they were weighed, full and empty, in a balance with 0.1g of precition. The intestine length was measured with a metric tape, in a scale with evaluation of 0.1cm. All data of the digestive organs were related to the body weight of pigs.

The morphometric measures of the GIT and the accessory glands were fitted to the body weight, as it is proceed in this type of study (Ly 1979). Data were handled according to the analysis of variance. The 2x2 factorial arrangement was followed (Steel *et al.* 1997) and an appropriate statistical package was applied (Minitab 2009). The sex effect was not taken into account.

Results

Two animals died, apparently for anoxia, at the moment of weighing, before the slaughter (Ly *et al.* 2013).

There was no significant effect in the interaction sex x diet. Equally, in the gastrointestinal macro-architecture and accessory glands, probably because all the measures were adjusted to the body weight, there was not any important effect for sex. In the high-test molasses treatment, only data of six animals were used to study the gastrointestinal macro-architecture, due to the two deaths before weighing and slaughtering the animals (Ly *et al.*2013).

The relative weight of the different digestive organs and the accessory glands are showed in table 1.

This research found that the relative weight of the GIT was numerically low in pigs fed with high-test molasses, regarding those that ingested maize diet. This dietetic effect was significant (P< 0.05) in the large intestine of those same animals. This considerable decrease of the large intestine was not noticed in the caecum, but it was present in the centripetal colon and centrifuge colon. The relative weight of the liver and pancreas of pigs fed with high-test molasses increases (P< 0.01) or decreases (P< 0.001), regarding the relative weight of these same organs in animals fed with maize.

Seemingly, the relative weight of the large intestine influenced in a remarkable way (r, 0.793; P<0.01) on the relative weight of all the GIT. Figure 1 shows all data about the fourteen animals examined in this research.

The percentage contribution of each digestive section, regarding the total of the tract is showed in table 2

In the percentage contribution of the stomach, there was a difference (P< 0.10) that showed that this organ contributes to the total contribution, with higher value in the diet of high-test molasses regarding the maize. There was no significant effect of the treatment on the caecum percentage contribution. The large intestine contributed

Table 1. Gastrointestinal macro-architecture and accessory glands of growing pigs, fed with maize or high-test molasses diets. Relative weight, g/kg of body weight [1]

	Maize	High-test molasses	SE ±
n	8	6	-
Stomach	5.52	5.85	0.33
Duodenum/jejunum	11.12	10.85	1.01
Jejunum/ileum	9.96	10.03	0.67
Small intestine	21.08	20.89	1.43
Caecum	1.94	2.03	0.19
Centripetal colon	10.29	8.16	1.17
Centrifuge colon	7.85	6.15	0.99
Large intestine	20.08	16.34	1.59*
Gastrointestinal tract	46.68	43.09	2.90
Accessory glands			
Liver	17.55	22.93	1.53**
Pancreas	0.99	0.64	0.08***

[1] Empty and fresh weight of the organs
* P < 0.05; ** P < 0.01; *** P < 0.001

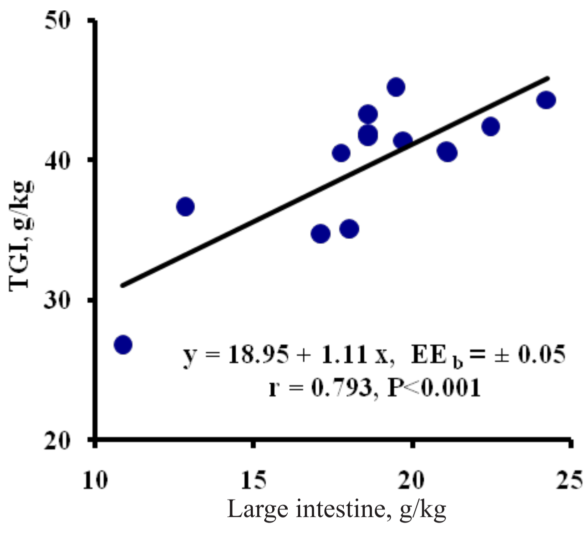

Figure 1. Interdependence between the relative fresh weight, regarding the body weight of the large intestine and the gastrointestinal tract of young pigs.

Table 2. Percentage contribution of the digestive organs of growing pigs fed with maize or high-test molasses diets[1]

	Maize	High-test molasses	SE ±
n	8	6	-
Stomach	11.82	13.58	0.62+
Duodenum/jejunum	23.82	25.18	1.33
Jejunum/ileum	21.34	23.28	0.99
Large intestine	45.16	48.48	2.09
Caecum	4.16	4.71	0.31
Centripetal colon	22.04	18.94	2.44
Centrifuge colon	16.82	14.27	1.77
Small intestine	43.02	37.92	2.33*
Gastrointestinal tract	100.00	100.00	-

1 % of all the tract of the empty and fresh weight
+ P < 0.10; * P < 0.05

significantly (P< 0.05) less to the total (37.9 %) with the high-test molasses, regarding the maize (43.0%).

Table 3 shows the data of the longitudinal measures and the intestinal linear density. Concerning the linear relative length, there was not effect of the treatment on any of the divided sections of the GIT, although the high-test molasses seemed to have determined slightly elongated small intestines (29.1cm/kg of body weight), compared with the maize (27.7cm/kg of body weight). Something similar seemed to happen with the length of the whole tract with the high-test molasses (37.1cm /kg of body weight), in contrast with the maize (35.6cm/kg of body weight). In the linear densities, the high-test molasses determined significantly (P<0.05) low values for the large intestine and for the value of all the GIT (2.08 and 1.01g/cm per kg of body weight), when it was compared with the maize (2.55 and 1.16g/cm per kg of body weight). There was not treatment effect for the caecum density and the colon.

Table 3. Longitudinal measures of the digestive organs of growing pigs, fed with maize or high-test molasses diets1

	Maize	High-test molasses	SE ±
n	8	6	-
Longitude, cm/kg of body weight			
Duodenum/jejunum	13.85	14.43	0.97
Jejunun/ileon	13.85	14.72	1.00
Small intestine	27.70	29.15	1.98
Ciego	0.42	0.47	0.03
Colon centrípeto	3.66	3.58	0.14
Colon centrífugo	3.87	3.90	0.24
Large intestine	7.94	7.96	0.35
Tracto gastrointestinal[2]	35.64	37.10	2.15
Linear density g/cm per kg of body weight			
Duodenum/jejunum	0.81	0.75	0.06
Jejunun/ileon	0.73	0.68	0.04
Small intestine	0.77	0.71	0.05
Ciego	4.75	4.30	0.45
Colon centrípeto	2.82	2.29	0.32
Colon centrífugo	2.09	1.63	0.29
Large intestine	2.55	2.08	0.20*
Tracto gastrointestinal	1.16	1.01	0.05*

[1] % of the total of the tract of the empty fresh weights.
[2]From duodenum to rectum. * P < 0.05

Discussion

According to the results of this research, the change of the carbohydrate source of the torula yeast had more influence on the relative weight of the large intestine, with clear decrease, in a relative and percentage way, in the diet with high-test molasses, regarding to the maize. This result could be due to a low activity in the large intestine, mainly in the colon. This could maybe be caused by the lack of dietetic important levels of fiber in the food consumed by animals. Anugwa *et al.* (1989) suggested that fiber diets could cause hypertrophy of the GIT, where the large intestine is included, expressed in the increase of their weight related to the body weight, in 14% with alfalfa diets. The data of this research indicate the opposite: an atrophy of 7.7% for the whole GIT, and 18.6% for the large intestine, in animals that consumed the high-test molasses diet, practically without fiber, regarding those that consumed maize. Taking into account the statements of De Lange *et al.* (2003), who refer that the cellular wall has to do with the performance of the carcass in pigs, in an inversely proportional way, because cellular wall usually determines higher amounts of digestive content in the GIT(Ly *et al.*2013). The opposite would happen in this research. The diet with high-test molasses seemed to contribute to a redistribution of the percentage with which participated the different sections of the GIT, if the considerable distribution in the maize diet were taken like the usually found in these measurements.

The interdependence verified between the weight of the large intestine and the whole GIT could indicate that in diets with source of so diverse carbohydrate as the used in this study, the considerable value of the whole tract could be known, only if the weight of the large intestine is determined.

The considerable decrease of the GIT could lead to a decrease in the energy required for maintenance, due to the high energy demand of the intestinal tissue (Koong *et al.*1982 and Koong *et al.*1983). A decrease of the energy required for the maintenance in pigs feeding with molasses could counteract, to a certain extent, the less food usage carried out by the pigs that consume this not conventional food resource (Ly 1996 and 2008).

The indexes of linear density of the intestines, that involve the considerable measures like longitudinal, could reflect the changes in the gastrointestinal macro-architecture. In this evaluation, pigs fed with high-test molasses showed large intestine and the whole alimentary canal, from the pylorus to the rectum, with less linear densities that those of the animals that ingested the maize diet. In the reviewed literature, there is no available information regarding this measure type in growing pigs, fed with diets of sugarcane molasses. Nevertheless, it has always been assumed that a less linear density, that is to say, a thickness reduction of the alimentary canal, is associated with a favorable gastrointestinal environment for a good use of the food given to the animals. The same happens when the pigs have been treated with antibiotics (Visek 1987). However, this effect was more marked in the large intestine than in the small intestine of pigs fed with high-test molasses. The elongation of the small intestine of the animals has been associated with better performance features in pigs (Petersson *et al.*1979).

The data related to the relative weight of the liver and pancreas of pigs fed with high-test molasses, in contrast with that found in animals consuming maize diet, could reflect, evidently, not only changes in the digestive process of the pigs, but also in the metabolic ones (Ly 1996). This dietetic effect so evident in the accessory glands of the food carcass, with minimum value of six replications in the high-test molasses diet contrasts with the inconsistency of the considerable and longitudinal values of the different sections of the GIT. In these sections, except for data from the large intestine, it seemed that a higher population size (n>8) is required to find possible differences among treatments. According to the results, growing pigs fed with high-test molasses diets as the only energy source, show clear differences in the gastrointestinal macro-architecture and accessory glands.

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