High-test molasses or maize as energy source for growing pigs. Distribution studies of digesta under fasting conditions

J. Ly

Instituto de Ciencia Animal, Apartado Postal 24, San José de las Lajas, Mayabeque, Cuba
Email: jly@ica.co.cu

The digestive content of 14 Yorkshire x Landrace x Duroc castrated male and female pigs, of around 55 kg of liveweight, was examined. Animals were fed *ad libitum* since the 30 kg, with diets of high-test molasses or maize, as the only energy source. After the slaughter, before the daily distribution of food, the digestive content of the centripetal colon tended ($P < 0.10$) to be higher with maize than with high-test molasses, and it was significantly ($P < 0.01$) higher regarding the halves of small intestine and caecum, while the gastric content and the content of the centrifuge colon did not differ. In both diets, the centripetal colon determined significantly ($P < 0.01$) the highest percentage contribution of fresh digesta, 43.4 and 33.7 % for maize and high-test molasses, respectively. The digestive content of all the tract was higher ($P < 0.10$) in the maize diet than in the high-test molasses (52.1 and 43.1 g/kg of body weight, respectively). Under fasting conditions, for both diets, the large intestine contributed with almost two thirds of all the fresh digesta found in the food carcass. It is suggested that, in growing pigs fed *ad libitum* with a diet of high-test molasses, a lower content of fresh digesta may be associated with higher values of digestibility, and therefore, with lower empty weight of the food carcass.

Key words: *pigs, digesta, high-test molasses, maize*

Previous studies, developed with slaughtered animals, analyzed several aspects related to different evaluations high-test molasses or maize digestion (Ly 1975, 1977). Even though, there is no information about the characteristics of the digesta under fasting conditions. These data are necessary for a good interpretation of the digestive process and for knowing the movement of digestive content in the food carcass, almost static topics in their studies (Rérat and Lougnon 1963, Ly 1975, 1977 and Kass *et al.* 1980) or dynamics, real or virtual (Wilfat *et al.* 2007 and Strathe *et al.* 2008). Even under conditions of virtual studies, information *in vivo* needs to be gathered (van Milgen and Lescoat 2008). This could happen in the case of diets with sugarcane molasses.

This study refers to the determination of the distribution of gastrointestinal digesta under fasting conditions

Materials and Methods

A total of 14 pigs were used, with around 55 kg of liveweight, distributed at random into two groups. Animals had been fed *ad libitum* since the 30 kg, with diets of high-test molasses or maize, as the only energy source (Ly *et al.* 2014a). Table 1 shows the most important details of the diets. Growing stage lasted six weeks. Other data related to lodging and animal management are stated in studies of Ly *et al.* 2014 a.

Pigs were slaughtered using a heart puncture, between 8:00 and 10:00 a.m., when the animals did not demonstrated a prandial activity. This period was the same in which the remaining food was collected, feeding troughs were cleaned and the new ration was added. The extraction of digesta contents from different organs of the food carcass has been described by Ly (1975).

Essentially, the digestive content marked the difference in weighing organs, full and empty, after performing the laparotomy, extracting the gastrointestinal tract (GIT) and bonding it with the cardias, pylorus and ileo-caecal valve. In the case of small intestine, it was divided into two equal halves, conventionally called duodenum/jejunum and jejunum/ileum. In the large intestine, after separating the caecum at the height of the ileo-caecal valve, the colon was divided into near colon and distant colon. It was bonded and cut in the coli flexure (Ly and Mollineda 1984).

Table 1. Diet composition (per cent under dry basis)[1]

Ingredients	Maize	High-test molasses
Maize meal	79.3	-
Sugarcane high-test meal	-	65.5
Torula yeast	18.0	32.5
Vitamins and minerals[2]	2.7	2.0
Analysis		
Starch	55.79	-
Sucrose and hexoses	-	51.15
Organic Matter	95.13	93.38
N	2.56	2.56

[1] Ly *et al.* (2013a)
[2] It includes vitamins and trace elements according to suggestions from NRC (1998)

Data were processed using a conventional statistical package (Minitab 2009). A 2 x 2 factorial arrangement was used, where the factors were diets, maize or high-test molasses, and the six sections in which the GIT was divided: stomach, duodenum/jejunum, jejunum/ileum, caecum, centripetal colon and centrifuge colon (Steel *et al.* 1997). Data were examined using the following linear model:

$Y_{ij} = \mu + A_i + B_j + AB_{ij} + \varepsilon_{ij}$

Where:

Y_{ij} is the value of one observation from the different variables

μ is the general mean

A_i is the effect of the i-th diet (i = 1, 2)

B_j is the effect of the j-th digestive section (j = 1,…6)

AB_{ij} is the interaction diet x digestive section

ε_{ij} is the effect of random error

All the effects of the model are considered as adjusted, except ε_{ij}, which was normally distributed. When the mean contrast showed significant differences (P < 0.05), they were separated using the test of Tukey.

Results and Discussion

Two animals died, apparently due to anoxia, at the moment they were weighed, before the slaughter. Details related are described in a study made by Ly *et al.* (2013).

There was no significant effect in the interaction diet x digestive section. Table 2 shows figures corresponding to digestive content of different sections of GIT. From the point of view of type of diet given to animals, digesta from the centripetal colon was noticed to be higher in the maize diet, regarding the diet with high-test molasses (P < 0.10). When comparing the digestive content among different sections of the GIT, the content of centrifuge colon was significantly higher (P < 0.01), regarding the rest of gastrointestinal sections, mainly both halves of small intestine and caecum. The amount of stomach digesta and the one from the centrifuge colon did not seem to differ significantly from the digesta of centripetal colon in the high-test molasses diet.

Table 3 shows the percentage contribution of fresh content from each digestive section to the whole tract. From the diet point of view, the percent of fresh digesta was lower in the duodenum/jejunum (P < 0.10) and in the centripetal colon (P < 0.01). The opposite happened in the percentage contribution of caecal digesta (P < 0.05). There was no diet effect in the stomach, jejunum/ileum, and centrifuge colon. When comparing the different sections, in both types of diets, the centripetal colon showed higher percentage contribution (P < 0.01) regarding the rest of different places within the food carcass. Out of all the examined sections, duodenum/jejunum showed lower percentage contribution to the fresh digesta.

Table 4 shows data corresponding to digestive content of all the small intestine, large intestine and GIT.

The digestive content of the small intestine and all the GIT was numerically lower (P < 0.10) in the high-test molasses than in the maize diet. This was also the results when examining the digesta content in the large intestine. From the percentage contribution of fresh digesta point of view, the large intestine contained in both diets around two third parts of all the digesta located in the food carcass.

This study considered six sections for evaluating digesta of GIT, but this decision was not a consequence of being in agreement with the general tendency, which is, apparently, inexistent. In studies of modeling digestive processes (Bastianelli *et al.* 1996 and Strathe *et al.* 2008) or partial digestibility (Kass *et al.* 1980), four digestive sections or compartments have been considered: stomach, two halves of small intestine, and large intestine. Jorgensen *et al.* (1996) also divided the tract into four parts in studies about the status of GIT and digestive content. However, they divided it into stomach, small intestine, caecum and colon. The GIT was divided into more fragments for other evaluations (Usry *et al.* 1991 and Rivest *et al.* 2000).

Under fasting conditions, this research demonstrated that pigs accumulate digesta into the large intestine, which should be the compartment to be subdivided in any type of particular study. Even more, out of all the sections from the large intestine examined in this study, the centripetal colon seemed to have a preponderant position regarding the content of fresh digesta.

It is suggested that growing animals, fed *ad libitum* with a diet of high-test molasses, a lower content of fresh digesta may be related to higher values of digestibility,

Table 2. Fresh digestive content of growing pigs, fed with high-test molasses or maize. Relative weight, g/kg of body weight under fasting conditions.

	Maize	High-test molasses	SE ±
n	8	6	-
Stomach	8.63[a]	8.20[ab]	1.65
Duodenum/jejunum	4.34[a]	2.84[a]	1.68
Jejunum /ileum	6.85[a]	4.16[a]	1.20
Caecum	3.36[a]	4.22[a]	0.75
Centripetal colon	22.32[b]	14.09[b]	2.88+
Centrifuge colon	6.65[a]	9.67[ab]	2.37
SE ±	2.71**	3.55**	-

[ab] Means without common letter in the same column differ significantly (P < 0.05) among them

+ P < 0.10 for diet effect

** P < 0.01 for digestive section effect

Table 3. Percentage contribution of fresh digesta from different organs of growing pigs fed with diets of maize or high-test molasses[1]

	Maize	High-test molasses	SE ±
n	8	6	-
Stomach	16.14[a]	21.64[a]	3.44
Duodenum/jejunum	8.36[a]	4.03[b]	2.29+
Jejunum /ileum	13.17[a]	10.05[ab]	2.28
Caecum	6.49[a]	12.10[ab]	2.61*
Centripetal colon	43.47[b]	33.76[c]	3.65**
Centrifuge colon	12.36[a]	18.39[a]	6.99
SE ±	3.68**	2.83**	-

[ab] Means without common letter in the same column differ significantly (P < 0.05) among them.
[1] Percent of all the tract of fresh digesta from the digestive sections
+ P < 0.10 for diet effect. ** P < 0.01 for digestive section effect

Tabla 4. Fresh digestive content of growing pigs fed with diets of maize or high-test molasses. Fasting conditions

	Maize	High-test molasses	SE ±
n	8	6	-
Relative weight, g/kg of body weight			
Small intestine	11.18	6.99	1.79+
Large intestine	32.32	27.98	6.21
Gastrointestinal tract	52.13	43.18	4.06+
Total per cent			
Small intestine	21.53	14.07	3.59+
Large intestine	62.33	64.25	4.12
Gastrointestinal tract	100.00	100.00	-

+ P < 0.10 for diet effect

and as a result, to lower empty weight of food carcass (Ly *et al.* 2014 a, b). This proposal may be the topic for an additional study.

Acknowledgements

Thanks to the technical work carried out at the Instituto de Investigaciones Porcinas, by Mr. M. Pérez and Mr. H. Hernández, and Mrs. Ana María Romero, Mrs. María del Carmen Buján, Mrs. Nidia Víctores and Mrs. Juana Rosa Plasencia, who helped in the precise registration of all data. Likewise, thanks to Dr. Marisol Muñiz, for her suggestions on the biometric treatment of results. Thanks also to the Posgrado de Ciencias Biológicas y Agropecuarias, Universidad Autónoma de Nayarit, México, for the help given for fulfilling a stay at the Instituto de Investigaciones Porcinas.

References

Bastianelli, D., Sauvant, D. & Rérat, A. 1996. Mathematical modeling of digestion and nutrient absorption in pigs. J. Anim. Sci. 74:1873

Jorgensen, H., XinQuian, Zh. & Eggum, B.O. 1996. The influence of dietary fiber and environmental temperatura on the development of the gastrointestinal tract, digestibility, degree of fermentation in the hind.gut and energy metabolism in pigs. British J. Nutrition 75:3656

Kass, M.L., van Soeset, P.J., Pond, W.G., Lewis, B. & McDowell, R.E. 1980. Utilization of dietary fiber from alfalfa by growing swine. 1. Apparent digetibility of diet components in specific segments of the gastrointestinal tract. J. Animal Sci. 50:175

Ly, J. 1975. Studies on the digesta distribution in the TGI of pigs fed high-test molasses or maize. Stomach phase. Cuban J. Agric. Sci. 9:291

Ly, J. 1977. Studies on the digesta distribution along the TGI of pigs fed high-test molasses or maize. 2. Intestinal stage. Cuban J. Agric. Sci. 11:47

Ly, J., Almaguel, R., Lezcano, P. & Delgado, E. 2014a. High-test molasses or maize as energy source for growing pigs. Performance traits and rectal digestibility. Cuban J. Agric. Sci. 48:

Ly, J., Almaguel, R., Grageola, F., Lezcano, P. & Delgado, E. 2014b. High-test molasses or maize as energy source for growing pigs. Digestive organs status. Cuban J. Agric. Sci. 48:

Ly, J. & Mollineda, A. 1983. Large intestine digestion of pigs fed molasses. 1. Morphologic aspects. Cuban J. Agric. Sci. 17:285

Minitab. 2009. Statistical Software. Minitab 15. Minitab In Company. State Collegue (Penssilvania), on-line version. Available on: http://www.minitab.com

Rérat, A. & Lougnon, J. 1963. Eetudes sur le transit digestif chez le porc. Annales de Biologie Animale, Biochimie, Biophysique 3:21

Rivest, J., Bernier, J.F. & Pomar, C. 2000. A dynamic model of protein digestion in the small intestine of pigs. J. Animal Sci. 78:328

Steel, R.G.D., Torrie, J.H. & Dickey, M. 1997. Principles and Procedures of Statistics. A Biometrical Approach. McGraw and Hill Book Company In Company (segunda edición). New York. 666 pp.

Strathe, A. B., Danfaer, A. & Chwalibog, A. 2008. A dynamic model or digestion and absorption in pigs. Animal Feed Sci. and Tech. 143:328

Usry, J.L., Turner, L.W., Stahly, T.S., Bridges, T.C. & Gates, R.S. 1991. GI tract simulation mmodel of the growing pig. Transaction of the American Society of Agricultural Engineers, 34:1879

Van Milgen, J. & Lescoat, P. 2008. Modélisation du fonctionnement digestif et du metabolisme chea le porc: une alternative a l´experimentation animale? Bulletin de la Academie Veterinaire de France, 161:435

Wilfart, A., Montagne, L., Simmins, H., Noblet, J. & van Milgen, J. 2007. Digesta transit in different segments of the gastrointestinal tract of pigs as affected by insoluble fibre supplied by wehat bran. British J. Nutrition 98:54

Received: february 25, 2013