A NOTE ON IN VITRO DIGESTIBILITY (PEPSIN/PANCREATIN) OF YAMS (Dioscorea alata) FOR PIGS

J. Ly1, F. Grageola1,2 and E. Delgado1,3

1 Instituto de Ciencia Animal, Apartado 24, San José de las Lajas, Cuba
email: jly@ica.co.cu
2 Autonomous University of Nayarit. City of Culture “Amado Nervo”. Tepic City. Nayarit, México
3 Faculty of Veterinary Medicine. National Autonomous University of Mexico. Tlaplan. Mexico City, México
email: enriquejesus@yahoo.com

SUMMARY

A 2 x 2 factorial arrangement with six replications was set out for evaluating the effect of method of processing (fresh or boiled at 100ºC) and peeled or not, on in vitro (pepsin/pancreatin) digestibility of DM, organic matter and N in six samples of Cuban yams (Dioscorea alata) currently found in local, Havana markets of human foods.

In vitro DM and organic matter digestibility were higher in boiled yams (55.3 and 72.6%) as compared to in natura tubers (39.3 and 50.0%). On the other hand, peeled samples showed a higher in vitro DM digestibility (60.2; P<0.01) and same held true for in vitro organic matter digestibility although with a lower degree of confidence (72.2%; P<0.05) as compared to unpeeled samples (34.2 and 50.4%). In vitro N digestibility followed the same pattern as influenced the same factors. Starch hydrolysis was consistently higher in those boiled samples than those in natura, and its in vitro digestibility was significantly linked to that of organic matter ($R^2$ = 0.641; P<0.008).

It is suggested that an important fraction of yam tubers should be digested in the large intestine of pigs, this being more accentuated if raw and unpeeled tuber would be given to the animals. The in vitro digestibility technique, simulating digestion up to ileum in pigs, may be a fast, cheap and safe method for discriminating among different yam cultivars, probably within a varied range of alternatives of tuber processing, either in small or great scale for producing pigs.

Key words: digestibility, ileal, pepsin, pancreatin, yams

Short title: In vitro digestibility of yams

DIGESTIBILIDAD IN VITRO (PEPSIN/PANCREATINA) DE ÑAMES (Dioscorea alata) PARA CERDOS

RESUMEN

Se usó un arreglo factorial 2 x 2 con seis réplicas para evaluar el efecto de métodos de procesar (fresco o hervido a 100ºC) y con o sin cáscara en la digestibilidad in vitro (pepsina/pancreatina) de la MS, la materia orgánica y el N, así como la amilólisis, de seis muestras representativas, cubanas, de ñames (Dioscorea alata) hallados habitualmente en mercados de alimentos para seres humanos de La Habana.

La digestibilidad in vitro de la MS y la materia orgánica fueron más altas en los ñames hervidos (55.3 y 72.6%) comparada con la de los tubérculos in natura (39.3 y 50.0%). Por otra parte, las muestras peladas mostraron una digestibilidad in vitro de la MS más alta (60.2%; P<0.05) y lo mismo fue así para la digestibilidad in vitro de la materia orgánica aunque con un grado de confiabilidad menor (72.2%; P<0.05) en comparación con las muestras sin pelar (34.2 y 50.4%). La digestibilidad in vitro del N siguió el mismo patrón influenciado por líquenes factores. La hidrólisis de almidón fue consistentemente más alta en las muestras hervidas que en las in natura y su digestibilidad in vitro estuvo significativamente vinculada con la de la materia orgánica ($R^2$ = 0.817; P<0.008).

Se sugiere que una fracción importante de los tubérculos de ñame se digiere en el intestino grueso de los cerdos, lo que sería más acentuado si se dieran tubérculos crudos y sin pelar a los animales. La técnica de digestibilidad in vitro, que simula la digestión hasta ileon en los cerdos, puede ser un método rápido, barato y seguro para discriminar entre distintas variedades cultivadas de ñames, probablemente dentro de una gama variada de alternativas de procesamiento de los tubérculos, ya sea en pequeña o gran escala de producción de ganado porcino.

Palabras claves: digestibilidad, ileal, pepsina, pancreatina, ñames

Título corto: Digestibilidad in vitro de ñames
INTRODUCTION

Yam is the common name of rhizomes of a perennial plant from the genus Dioscorea in the family Dioscoreaceae, originating edible tubers which are often used as human, staple food, particularly in Africa and India (Coursey 1965, 1967; Onwueme 1978; Mandal 2006). Besides, in many rural areas not marketable yams are used as animal feedstuff in backyard livestock economies.

Although pigs are animals included in the category of those individuals which are usually fed with yams not directed to humans, very few is known in America about its nutritive (Marin and Gallo 1973; Blanco et al 2004) or feeding value (Esnaola 1986) in this animal species. Nevertheless, current information arising from Africa is mainly concerned to the use of yam as such or its residues in monogastric animal species, such as poultry and rabbits (Akinmutimi et al 2006; Akinmutimi and Onen 2008; Ayoola and Akinbani 2011; Darra et al 2011; Inaku et al 2011; Edache et al 2012; Lawal et al 2012).

The aim of the present report is to inform about the in vitro (pepsin/pancreatin) digestibility of yams, and of some factors that could influence its nutritive value, at least up to ileum. The experiment herein described followed the same pattern of conduction of others already published concerning the nutritive value of sweet potatoes (Ly et al 1999), taros and cocoyams (Ly and Delgado 2005) and cassava roots (Ly et al 2010).

MATERIALS AND METHODS

A total of six representative samples of either peeled or unpeeled, tubers in fresh and dry state from yams (Dioscorea alata) of unknown cultivars were investigated for chemical composition, and in vitro (pepsin/pancreatin) digestibility.

The tubers (table 1) were bought locally in six different markets in Havana City, in a lapsus of one week, and were commonly destined to human consumption. A specific selection was made, in the sense that small size tubers were bought, since this type of material is less preferred by consumers, and these yams are what are finally discarded or used for animal feeding. Overall, one to two kg of yams was obtained in every market place. The tubers were prepared fresh or boiled following procedures already described (Ly et al 1999). In this sense, peel was carefully separated from flesh by hand grating. Cooking of tubers was made by boiling chopped samples of yams during one hour, in the proportion of 1:10, weight basis. Thereafter the yams were let to refresh and then crushed and thoroughly homogenized.

The DM, ash, ether extract, crude fibre and N analyses were conducted according to standard AOAC (1995) methods, whereas the in vitro (pepsin/pancreatin) incubations, simulating in vivo, ileal digestibility, were conducted in all samples as outlined by Dierick et al (1985). All analyses were conducted in duplicate. The in vitro digestibility was determined in raw and cooked samples of peels and peeled tubers, as previously described (Ly and Delgado 2005; Ly et al 2010). In addition, rate of starch hydrolysis was conducted according procedures already described elsewhere (Ly et al 2010). Rice starch, reagent grade, was incubated as substance reference in in vitro determinations.

Six replicates, each representing that sample obtained in every one of the six markets, were use for each of six treatments, peeled and unpeeled, fresh and dried tubers, according to a 2 x 2 factorial arrangement. In the case of the chemical composition, the evaluation was conducted considering a one way classification for the effect of peeling and the same was considered by the effect of processing. The technique of analysis of variance was used for contrasting the means (Steel et al (1997). The Minitab (2009) software was employed for manipulation of data.

RESULTS AND DISCUSSION

Table 2 shows details concerning the chemical composition of yams as influenced by the effect of peeling the samples. There were no significant differences (P>0.05) related to the type of peeling, except for ash and crude fibre content, which values were higher in unpeeled samples. The same held true for the effect of processing, with the exception of the ash content, being lower in cooked tubers (P<0.05). Starch content was predominant in yams, and accounted for some 74.2-83.1% of the NFE fraction. Overall, chemical composition of yams coincided with that of other reported values in America (see for example, Blanco et al 2004).
Table 2. Chemical composition of yam tubers (percent in dry basis)

<table>
<thead>
<tr>
<th></th>
<th>DM</th>
<th>Ash</th>
<th>Crude fibre</th>
<th>Ether extract</th>
<th>NFE</th>
<th>Starch</th>
<th>Crude protein</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peeled</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>unpeeled</td>
<td>29.82</td>
<td>6.63</td>
<td>4.14</td>
<td>0.85</td>
<td>87.87</td>
<td>65.27</td>
<td>5.50</td>
</tr>
<tr>
<td>SE ±</td>
<td>1.01</td>
<td>0.23*</td>
<td>0.58*</td>
<td>0.16</td>
<td>2.22</td>
<td>1.50</td>
<td>1.01</td>
</tr>
<tr>
<td>Raw</td>
<td>30.50</td>
<td>6.89</td>
<td>3.15</td>
<td>0.88</td>
<td>84.58</td>
<td>67.40</td>
<td>4.50</td>
</tr>
<tr>
<td>Boiled</td>
<td>31.49</td>
<td>4.83</td>
<td>3.00</td>
<td>0.91</td>
<td>86.08</td>
<td>66.75</td>
<td>5.18</td>
</tr>
<tr>
<td>SE ±</td>
<td>0.77</td>
<td>0.35*</td>
<td>0.50</td>
<td>0.20</td>
<td>2.00</td>
<td>1.18</td>
<td>0.76</td>
</tr>
</tbody>
</table>

* P<0.05

Data concerning in vitro (pepsin/pancreatin) digestibility are listed in table 3. In vitro DM, organic matter and starch digestibility, as conducted by triplicate in rice starch as substrate of reference, resulted to be very high, 97.2, 98.0 and 95.5% respectively.

A non significant (P>0.05) interaction was detected in any or the evaluated indices. It was found that in vitro DM and organic matter digestibility were higher in boiled yams as compared to in natura tubers. On the other hand, peeled samples showed a higher in vitro DM digestibility (P<0.01) and the same held true for in vitro organic matter digestibility, although with a lower degree of confidence (P<0.05). In vitro N digestibility followed the same pattern found in in vitro DM and organic matter digestibility. Protease inhibitors presence in yams is controversial. Although Akinmutimi and Onen (2008) did not reported trypsin inhibitor presence in Nigerian yam peels, it has been found trypsin and chymotrypsin inhibitor activities together with that of α-amylase inhibitor activity in different types of Indian yam samples (Sasikaran et al 1999; Shanthakumari et al 2008). In fact, Shanthakumari et al (2008) observed that boiling Dioscorea alata during 90 minutes did not decrease trypsin inhibitor activity, thus supporting the herein listed data concerning in vitro N digestibility o yam samples. Therefore, the presence of protein hydrolase inhibitors could strongly influence protein digestibility of diets where yam products should be included. Furthermore, since starch content is considerably high in the tubers (Coursey 1967; Blanco et al 2004), in vitro DM and organic matter digestibility of yams could be indicating a poor starch hydrolysis. Marin and Gallo (1973) reported a low rectal DM digestibility of yam (Dioscorea alata) meal in pigs, 69%, when it was determined by difference.

Table 3. In vitro (pepsin/pancreatin) digestibility of yam tubers

<table>
<thead>
<tr>
<th></th>
<th>Fresh</th>
<th>Boiled</th>
<th>SE ±</th>
<th>Unpeeled</th>
<th>Peeled</th>
<th>SE ±</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digestible</td>
<td>39.33</td>
<td>55.31</td>
<td>4.00*</td>
<td>34.24</td>
<td>60.20</td>
<td>3.98**</td>
</tr>
<tr>
<td>Dry matter</td>
<td>50.03</td>
<td>72.63</td>
<td>2.14*</td>
<td>50.46</td>
<td>72.20</td>
<td>3.03*</td>
</tr>
<tr>
<td>Organic matter</td>
<td>63.00</td>
<td>88.54</td>
<td>2.00*</td>
<td>64.15</td>
<td>88.85</td>
<td>1.95**</td>
</tr>
<tr>
<td>Starch</td>
<td>15.33</td>
<td>45.58</td>
<td>3.67**</td>
<td>20.01</td>
<td>40.90</td>
<td>4.05**</td>
</tr>
</tbody>
</table>

* P<0.05; ** P<0.01

Aumaitre et al (1968) and Cerning-Beroard and Le Dividich (1976)found that in vitro starch hydrolysis of yam samples was not high, and otherwise lower than that of other tropical starch sources,such as sweet potato, bananas and taro, either cooked or not. This information is in agreement with others arising from in vitro digestibility of other roots and tuber found in Cuba (Ly and Delgado 2006; Ly et al 1999, 2010).

Besides, the rate of starch hydrolysis during the first hours of incubation was greatly increased in cooked yam starch. On the other hand, Marin and Gallo (1973) found that rectal, in vivo digestibility of DM was very low, 69%. Marin and Gallo (1973) considered that experiments should be conducted to study the influence of heat on yam nutrient digestibility. Niba (2003) found that slowly digested starch in yam samples were not high, 4.95 g/100 g, as compared to other types of starch such as maize, 22.2 g/100 g. In this connection, resistant starch found in Costarricean yam samples resulted to contain very low values (Blanco et al 2004).

On the other hand, parboiling and autoclaving determined and increase in this type of starch, when contrasted with raw samples of starch. In this connection, it has been found that amylase inhibitors present in yams are not completely neutralized by soaking, cooking or autoclaving samples from seven Dioscorea species, Dioscorea alata included (Shanthakumari et al 2008). Similar findings have been provided by Rekha and Padmaja (2002).

Therefore, Indian data could support the rather slow amylolysis observed of yam samples found in the current investigation, which in turn could be probably due to α-amylase inhibitors activity rather than higher amounts of unavailable starch. A rather straight relationship was encountered when in vitro organic matter and starch digestibility were associated, the regression analysis revealing a good confidence (P<0.01) for a linear interdependence. This relationship is presented in figure 1.
In vitro digestibility of yams/Digestibilidad in vitro de ñames

It is suggested that an important fraction of yam tubers should be digested in the large intestine of pigs, this being more accentuated if raw and unpeeled tuber would be given to the animals. In this connection, Wang et al (2007) have found changes in caecal fermentative pattern in mice fed raw yam tubers. It is considered that more research should be undertaken in order to determine in pigs, in vivo, the nutritive value of yam tuber materials, particularly in the area of neutralization of antinutritional factors, in the manner that it has been claimed by other (Soetan and Oyewole 2009; Lawal et al 2012).

ACKNOWLEDGMENTS

Thanks are given to Mrs. Martha Carón, for her skilful assistance to the chemical analyses, and to Dr. Marisol Muñiz, Swine Research Institute at Havana, for her advice concerning the biometrical procedures employed in the current investigation. The authors are grateful to personnel belonging to the Library of the Cuban Ministry of Agriculture, Havana, and the Institute of Animal Science, San José de las Lajas, for facilitating the consultation of several documents herein referred.

REFERENCES


Coursey, D.G. 1965. The role of yams in West African food economy. World Crops, 17:74-82


Marín, H. and Gallo, J.T. 1973 Digestibilidad y energías digestible y metabolizable del azúcar de caña (Saccharum officinarum L.) y del hene (Dioscorea alata) en cerdos. Revista ICA (Instituto Colombiano Agropecuario, Bogotá), 8:145-156


