DETERMINATION OF THE DIGESTIBILITY OF SOME PLANT INGREDIENTS FOR GRASS CARP (*Ctenopharyngodon idella)*

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ABSTRACT

The present study aimed at evaluating the apparent digestibility of rice bran, corn meal and cassava meal for grass carp (*Ctenopharyngodon idella)*. The digestibility of nutrients of these plant-ingredients were determined using the indirect method with the incorporation of Cr_2O_3. Rice bran appeared to have a high digestibility of dry matter (80.3%), protein (87.9 %) and ash (97.4 %) for grass carp. Corn meal has also high digestibility of dry matter (88.9%), protein (84.9%) and ash (92.7%). There was no statistically significant difference when comparing the digestibility of protein and ash between rice bran and corn meal for grass carp. The dry matter, protein and minearl digestibility of cassava was 80.3%, 87.9% and 14.3%, respectively, and appeared to be inferior to rice bran or corn meal. Our results indicated that the grass carp digests rice bran and corn meal better than cassava meal.

Keywords: Cassava meal, corn meal, digestibility, grass carp, rice bran.

Xác định độ tiêu hóa của một số nguyên liệu thực vật đối với cá trắm cỏ (*Ctenopharyngodon idella*)

TÓM TẮT

Nghiên cứu này nhằm mục đích xác định độ tiêu hóa của cá trắm cỏ (*Ctenopharyngodon idella*) đối với 3 loại nguyên liệu là cám gạo, bột ngô và bột sắn. Việc xác định độ tiêu hóa của các dưỡng chất trong các nguyên liệu có nguồn gốc thực vật được thực hiện theo phương pháp gián tiếp có sử dụng chất đánh dấu Cr_2O_3. Cám gạo cho kết quả cao về độ tiêu hóa vật chất khô (80,3%), protein (87,9%) và chất khoáng (97,4%). Tương tự bột ngô cũng cho kết quả khá cao về độ tiêu hóa vật chất khô (88,9%), protein (84.9%) và chất khoáng (92,7%). Không có sự khác biệt có ý nghĩa thống kê khi so sánh độ tiêu hóa các dưỡng chất của cám gạo và bột ngô đối với cá trắm cỏ. Độ tiêu hóa chất khô, protein và chất khoáng của bột sắn lần lượt là 80,3%, 87,9% và 14,3% và thấp hơn so với của cám gạo và bột ngô. Kết quả bước đầu này cho thấy cá trắm cỏ tiêu hóa cám gạo và bột ngô tốt hơn bột sắn.

Từ khóa: Cám gạo, bột ngô, bột sắn, độ tiêu hóa, trắm cỏ.

1. INTRODUCTION

Presently, in the aquaculture industry, there is the need to reduce the use of costly and scare fish meal and fish oil (Sargent and Tacon, 1999; Naylor et al., 2000; FAO, 2007). As a strategy to reduce risk, the identification, development and use of plant ingredients in aquafeeds remains a high priority. Two aspects of nutrition are critical to the long-term sustainability of aquaculture: the identification of alternative ingredients to fish meal and the development of diets that reduce the release of nitrogen and phosphorus into the environment (Donaldson, 1997). Several studies investigating alternative ingredients to replace fish meal have shown promising results using plant ingredients (Gomes et al., 1995; McGoogan and Gatlin, 1997; Mukhopadhyay and Ray, 1999; Forster, 2002; Lee et al., 2002; Pereira and Oliva-Teles, 2003; Chou et al., 2004; Glencross et al., 2004). Alternative plant ingredients help reduce price, alleviate pressure on the stagnant industrial fish supply, and promote sustainability.

Grass carp is one of the most popular fresh water fish in Northern Vietnam. The grass carp is a member of the Cyprinid family (*Cyprinidae*). This species was identified as a herbivorous fish. Some aquatic weeds, larvae, zooplankton are nutrient sources of grass carp in nature. Under culture conditions, grass carp can well accept artificial feed such as the by-products from grain processing and vegetable oil extraction meals, and pelleted feeds, in addition to aquatic weeds and terrestrial grasses (Dongmeza, 2009).

The digestibility of ingredients is one of the most important data to formulate least-cost feed formulation in aquaculture feed. Digestibility is determined by comparing the quantity of nutrient consumed with that present in the feces at the end of the digestive process (Sullivan and Reigh, 1995). Up to now, only few feed ingredients currently used for grass carp in Vietnam have been assessed for their digest value. Thus, the main objective of this study is to determine the digestibility of some plant ingredients for grass carp. This study was conducted in laboratory conditions and the information gained is a good base for scientists and extension workers to develop feed strategies based on plant ingredients for grass carp.

2. MATERIALS AND METHODS

Rice bran, corn meal and cassava meal are three plant-ingredients originated from Son La Province, Viet nam. Each ingredient was milled to produce the powder with a maximum particle size of 500 μm. They were finely ground in order to ensure the homogeneity in the finished diet (Burel et al., 2000; Glencross et al., 2004a). In addition, particle size has been considered as an important factor affecting the ingredient evaluation process (Kaushik, 2001; Nir and Ptichi, 2001; Glencross et al., 2007).

2.1. Method in digestibility study

The apparent digestibility coefficients (ADC) of dry matter, protein, ash and lipids of rice bran, corn meal and cassava meal were calculated indirectly using chromic oxide as an inert marker by the method of substitution (Sugiura et al., 1998; Bureau et al., 1999). A reference diet was prepared containing 1 % chromic oxide. Three test diets were made by mixing 70 % of the reference diet mixture and 30 % of rice bran or corn meal or cassava meal to be tested (correspond with rice bran diet, corn diet and cassava diet, respectively). The diets were pelleted using a pellet mill (5 mm in diameter) and stored at 4°C. Table 1 shows the ingredients used in the reference and three test diets.

The digestibility experiment was carried out with three replicates per treatment in a thermoregulated water system with grass carp. Each group of 10 grass carp (about 250 g) was stocked into a 500-l cylindroconical tank. Water temperature, water quality and light regime were the same in all experimental tanks.

Table 1. Ingredient composition of the experimental diets used in the digestibility measurement of rice bran, corn meal and cassava meal

Ingredients	Reference diet (%)	Rice bran diet (%)	Corn diet (%)	Cassava diet (%)
Wheat meal	9.7	6.8	6.8	6.8
Fish meal	52.0	36.2	36.2	36.2
Fish oil	3.3	2.3	2.3	2.3
Vitamin mixture	2.0	1.4	1.4	1.4
Mineral mixture	2.0	1.4	1.4	1.4
Soybean meal	30.0	20.9	20.9	20.9
Rice bran		30.0		
Corn meal			30.0	
Cassava meal				30.0
Cr_2O_3	1.0	1.0	1.0	1.0
Total	100.0	100.0	100.0	100.0

The fish were fed by hand to visual satiety once a day. After 7 days of acclimatization with the reference and test diets, the feces collection was started. The feces were collected for 10 days from each tank. For each diet, fecal samples were collected daily and frozen. At the end of the experiment, feces were dried. All diets and feces were analyzed for dry matter, protein, lipid, ash and chromic oxide contents.

The ADC of the reference diet were calculated according to the following formulae:

ADC of DM of diet (%) = 100 x [1 - (dietary Cr_2O_3/fecal Cr_2O_3)]

ADC of nutrients of diet (%) = 100 x [1 - (dietary Cr_2O_3/fecal Cr_2O_3) x (fecal nutrient concentration/dietary nutrient)]

The ADC of dry matter, nutrients in the tested ingredient were calculated according to the following formulae:

ADC of DM of test ingredient (%) = (ADC of DM of the test diet - 0.7 x ADC of DM of the reference diet)/0.3

ADC of nutrient of test ingredient (%) = [(nutrient in test diet x nutrient ADC of the test diet) - (0.7 x nutrient concentration in reference diet x nutrient ADC of the reference diet)]/(0.3 x nutrient concentration in ingredient)

Values were expressed in % of dry matter.

2.2. Chemical analyses

Proximate analyses of dry matter, crude protein, crude lipid and crude ash of the samples were conducted using the following standard procedures (AOAC, 1995): dry matter by drying at 105°C for 24 h, ash by incineration at 550°C for 12 h, crude protein (N x 6.25) by the Kjeldhal method after acid digestion, crude lipid by the Soxhlet method. The determination of chromium III (trivalent) that involves digestion of organic matter, solubilisation of chromium and determination of chromium was conducted by photometry (Czarnocki et al., 1961; Fenton and Fenton, 1979).

2.3. Data analysis

Data was examined by one way ANOVA using SAS version 8 (SAS Institute, Cary, NC, USA) software. Levels of significance were determined using the Duncan test, with critical limits being set at $P<0.05$.

3. RESULTS AND DISCUSSION

3.1. Chemical composition of the plant-ingredients and experimental diets

Three plant-ingredients used in this study were originated from Son La. Their chemical compositions were analyzed before the determination of its digestibility for grass carp. The chemical compositions of rice bran, corn meal and cassava meal are shown in Table 2.

In general, the chemical composition of ingredients has influence on the digestibility of its nutrients. The chemical composition of rice bran, corn meal and cassava meal in literature was presented in Table 3.

The chemical compositions of three plant-ingredients in this study were not much different with those used in many other researches. Many authors reported the values ranging between 87.4 - 91.7%; 11.2 - 13.7%; 12 -17.9%; 7.4 - 13.6, respectively, for dry matter, protein, lipid and ash of rice bran (Table 3). The chemical composition of rice bran in our study was in this range as shown in table 2. However, the ash of corn meal and cassava meal in this study were slightly higher than that reported in literature. This high value of ash can influence the digestibility of other nutrients of ingredients. Four experimental diets were formulated as present in table 1. After pelleting, the diets were analyzed for chemical composition and the results are shown in table 4.

Table 2. Chemical compositions of studied ingredients

Ingredients	Dry matter (%)	Protein (%)	Lipid (%)	Ash (%)
Rice bran	92.7	13.8	14.8	8.4
Corn meal	88.2	9.1	4.8	7.9
Cassava meal	90.4	2.4	0.7	2.2

Table 3. The chemical composition of rice bran, corn meal and cassava meal in literature

Ingredients	Dry matter (%)	Protein (%)	Lipid (%)	Ash (%)	References
Rice bran	87.8	13.1	13.3	8.0	Hien et al., 2010
Rice bran	91	12.8	13.7	11.6	NRC, 1993
Rice bran	87.4	11.2	12.8	9.3	National Institute of Animal Husbandry, 2002
Rice bran	91.7	12.6	12	7.4	Hien et al., 2010
Rice bran	89	13.7	17.9	13.6	National Institute of Animal Husbandry, 2002
Corn meal	88	8.5	3.6	1.3	NRC, 1993
Corn meal	87.7	10.2	4.8	1.6	Hertrampf và Piedad, 2000
Casava meal	87	0.9	1.7	0.7	NRC, 1993
Casava meal	81.5	0.9	0.6	0.7	National Institute of Animal Husbandry, 2002

Table 4. Chemical composition of the experimental diets used in the digestibility study

Diets	Dry matter (%)	Protein (%)	Lipid (%)	Ash (%)
Reference	97.65	30.58	10.7	21.86
Rice bran diet	93.49	26.28	11.5	16.20
Corn diet	93.35	24.41	9.1	14.42
Cassava diet	95.06	26.83	8.9	18.50

3.1. The digestibility of dry matter

The digestibility of dry matter of three plant- ingredients for grass carp is presented in table 5

The dry matter digestibility of rice bran and corn meal was more than 80% and there was no significant difference between these two ingredients (table 5). The dry matter digestibility of cassava was significant lower ($P<0.05$) than rice bran and corn meal but remain high. Law (1986) reported the dry matter digestibility of corn meal for grass carp was 64.76%, which was lower than that obtained in our study (88.96%). In the other study, the dry matter digestibility of corm meal for tilapia was 82.21% (Guimaraes et al., 2009),. This digestibility value was high and comparable with our result. The dry matter digestibility of cassava for Mekong river catfish was 83.2% (Hien et al., 2010) and very close to dry matter digestibility for grass carp in this work. Guimaraes et al. (2009) determined 55.6% dry matter digestibility of rice bran for tilapia and much more inferior than that determined in this study for grass carp. We can explain this difference by the difference of ingredient source or by the difference of digest capacity between grass carp and tilapia. If the last is true, we can consider grass carp digest rice bran much better than tilapia.

3.2. The digestibility of protein

Table 6 shows the digestibility of protein of three plant-ingredients for grass carp.

Table 5. Digestibility of dry matter of three plant - ingredients for grass carp

Diets	Rice bran	Corn meal	Cassava meal
Digestibility of dry matter (%)	80.33 ± 0.29^{a}	88.96 ± 0.15^{b}	81.89 ± 12.23^{b}

^{a,b} Within a row, means lacking a common superscript setter differ ($P<0.05$). Data are means of three replicates with standard error (SE).

Table 6. The digestibility of protein of three plant - ingredients for grass carp

Ingredients	Rice bran	Corn meal	Casava meal
Digestibility of protein (%)	87.94 ± 0.17^{b}	84.89 ± 0.12^{b}	77.15 ± 10.22^{a}

[a,b] Within a row, means lacking a common superscript setter differ (P<0.05). Data are means of three replicates with standard error (SE).

Some authors reported that the apparent protein digestibility coefficients of plant ingredients such as rice bran, banana leaf, bamboo leaf, maize leaf in grass carp varied between 28.4% to 92.9% (Hertrampf and Piedad, 2000; Dongmeza et al., 2009). The protein digestibility value for rice bran, corn meal and cassava meal in the present study was found in this range. The high protein digestibility (87.94%) demonstrates that rice bran protein is highly available for grass carp. This value is also higher than that reported in American catfish (71 %; Hepher, 1988 or 76%; Halver and Hardy, 2002) and in grouper (59.5%; Laining et al., 2003). The protein digestibility of corn meal for grass carp in this study is higer than that for tilapia as reported by Law (1986) and higher than that for American catfish (60%; Halver et al., 2002). The cassava meal appears to have a lower protein digestibility (77.15%) than rice bran and corn meal. Hien et al. (2010) found the digestibility of protein of cassava meal for Mekong river catfish was very low with the value of 35.8%, so two times less than the result of our study for grass carp. This big difference of the digestibility can be explained by the interspecific variation and by a variation in the quality of cassava meal sources between studies.

3.3. The digestibility of ash

The digestibility of ash (or crude ash) of three plant-ingredients is reported in table 7.

The digestibility of ash of rice bran and corn meal was higher in grass carp in comparison to cassava meal. The anti-nutritional factors present in cassava meal may affect apparent digestibility of ash (NRC, 1993). The anti-nutritional factors can interfere with digestion by binding to digestive enzymes or by binding directly to some mineral elements (Francis et al., 2001), thus, reduce their availability for fish.

3.4. The digestibility of lipid

The source of rice bran, corn meal and cassava meal used in the present study showed a lipid digestibility of 82.4%, 80.6% and 71.3%, respectively (table 8). The lipid digestibility of cassava was significantly lower than that of corn meal (P<0.05). Lipid digestibility of rice bran for grass carp was highest in comparison with corn and cassava meal.

Table 7. The digestibility of ash of three plant-ingredients for grass carp

Ingredients	Rice bran	Corn meal	Casava meal
Digestibility of ash (%)	97.4 ± 0.78^{a}	92.66 ± 0.58^{b}	14.33 ± 95.58^{a}

[a,b] Within a row, means lacking a common superscript setter differ (P<0.05). Data are means of three replicates with standard error (SE).

Table 8. The digestibility of lipid of three plant-ingredients for grass carp

Ingredients	Rice bran	Corn meal	Casava meal
Digestibility of lipid (%)	82.4 ± 0.98^{a}	80.6 ± 0.7^{b}	71.3 ± 0.42^{c}

[a,b,c] Within a row, means lacking a common superscript setter differ (P<0.05). Data are means of three replicates with standard error (SE).

4. CONCLUSION

This study has showed that grass carp digested more dry matter, protein, ash and lipid from rice bran and corn meal than from cassava meal. Rice bran appeared to have a high digestibility of dry matter (80.3%), protein (87.9 %) and ash (97.4 %) for grass carp. Corn meal have also high digestibility of dry matter (88.9%), protein (84.9%) and ash (92.7%). The dry matter, protein and ash digestibility of cassava was 80.3%, 87.9% and 14.3%, respectively. Additional research is needed to determine the digestibility of energy in these plant ingredients to facilitate least-cost diet formulation for grass carp.

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