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Determination of Digestible and Metabolizable Energy of Fishmeal and Soybean Meal in Rainbow Trout with Two Different Sizes (*Oncorhynchus mykiss*)

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Abstract: The present research carried out to measure digestible (DE) and Metabolizable Energy (ME) for fishmeal and soybean meal in rainbow trout with two different sizes (120 and 220 g mean body weights). DE and ME are evaluation systems for feedstuffs and also, necessary for diet formulation. The fishes were maintained in metabolic chamber with single ingredient assay of feeding and chromic oxide (Cr_2O_3) was used as an external marker using total fecal collection method. Gross energy and chromic oxide values measured in feces, fishmeal and soybean meal. The results indicated that DE of fishmeal was 3700 and 3591 kcal kg^{-1} in 120 and 220 g body weight rainbow trout, respectively. Soybean meal had 3004 and 2889 kcal kg^{-1} respectively. Calculated ME from DE were 3204 and 3110 kcal kg^{-1} for fishmeal and 2601 and 2502 kcal kg^{-1} for soybean meal in 120 and 220 g rainbow trout, respectively. The results showed that rainbow trout can utilize fishmeal more efficiently than soybean meal.

Key words: Rainbow trout, digestible and metabolizable energy

INTRODUCTION

Digestible energy and metabolizable energy are both used as measures in expressing feedstuff nutritive evaluation in order to determine energy requirements of animals. Digestible energy is a part of energy intake absorbed in digestive tract and metabolizable energy refers to digestible energy minus the energy lost in exogenous excretions (urine and through gills) (Willoughby, 1999). Different feedstuffs provide various amounts of energy when used by fish as energy sources (Tibbetts *et al*., 2006). It seems rainbow trout utilize animal sources of protein and energy more efficient than plant sources (Murray *et al*., 2007; Ozogul *et al*., 2006). It is economically important to determine nutritive value of feedstuffs specially plant sources when formulating diets for fishes, because when plant sources of protein and energy used in diet of rainbow trout are not utilized efficiently by fishes, will lead to low performance (Baily and Alanara, 2006; Jobling, 1994). There are two basic methods measuring digestibility: direct and indirect. The direct method measures total food intake with collection of total feces while the indirect method uses a (external or internal) marker, or indicator, with sufficient samples of feces (Willoughby, 1999). Digestibility and digestible coefficient have been measured for various nutrients in certain feedstuff (NRC, 1993; Yusefi, 2000). Nouee and Choubert (1985) obtained the digestibility of Chironomidea and Gamaridea larvae for rainbow trout using indirect method by employing the chromic oxide (Cr_2O_3) as a marker. Cravedi *et al*. (1983) determined carbohydrate digestibility by fecal collection using Cr_2O_3 as a marker. The objective of present study was to compare fishmeal and soybean meal in rainbow trout with two different sizes regarding their digestible and metabolizable energy content, indirect method using.

MATERIALS AND METHODS

Eight cylindroconical tanks each 100 L in volume, called Zoug were used as a flow through metabolic chambers. To minimize the environmental fluctuations tanks were placed in an indoor room. The experiment was carried out with two groups of rainbow trout weighing 120 g (assigned group A) and 220 g (assigned group B) for two different feedstuffs of fishmeal and soybean meal. Table 1 shows the characteristics of the fish meal and soybean meal used in the experiment. Throughout the experimental period the water criteria such as temperature, dissolved oxygen and pH remained constant, 15±1°C, 8.5 mg L^{-1} and 7.6, respectively. The feedstuffs (fish meal and soybean meal) were first completely milled and mixed with 1% chromic oxide (Cr_2O_3) as external marker and then shaped as pellets by a pellet set. In each stage, one fish was put in the tank and following adaptation period of 10 days, it was starved for 48 h until

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Table 1: Chemical composition of fish meal and soybean meal

Feed stuff	Dry matter (%)	Crude protein (%)	Crude fat (%)	Ash (%)	Crude fiber (%)
Fish meal	92	62.5	8.2	16.37	0.9
Soybean meal	90	41.14	1.2	7.2	6.1

its digestive track was completely evacuated. Then each of the feedstuff was offered to the fish separately up to satiation by the single ingredient assay method. Thereafter feces were collected through the tank drain. The experiment was repeated for 7 days in order to collect enough fecal waste from the fish. The collected feces were immediately transferred to laboratory and remained freeze at -20°C until analysis (Baily and Alanara, 2005). Determination of energy and chromic oxide contents of feedstuffs was carried out using AOAC method (Willoughby, 1999).

Upon obtaining the data from the analyses of feedstuffs and feces, nutrient digestibility was calculated using the following formula (Jobling, 1994; NRC, 1993; Willoughby, 1999):

$$\text{Digestibility coefficient} = \frac{100 - 100(\%\text{Feed } Cr_2O_3)}{(\%\text{Feces } Cr_2O_3)} \times \frac{(\text{Energy in feces})}{(\text{Energy in feed})}$$

Metabolizable Energy (ME) of each food item was then calculated by subtracting the amount of energy lost through the Nitrogenous Excretion (NE) from the digestible energy. The energy loss through NE was considered as 11% of the intake energy, as stated by Willougby (1999).

RESULTS AND DISCUSSION

The energy content of fishmeal, soybean meal and feces produced by group A and B fish together with the chromic oxide content of foodstuffs and feces for corresponding groups results show a higher loss of energy through feces when fish was fed soybean meal diet (Table 2).

The formula mentioned earlier, the percentage of nutrient digestibility and digestible energy of each feedstuff for group A and B fish were calculated.

The results indicated that the digestibility of diet is affected both by the nature of the feedstuffs and size of the fish, hence influencing the amount of digestible energy available to fish. Consequently, the lowest values of digestibility and digestible energy were obtained for soybean meal and the highest for fish meal (group B 220 g fish) (Table 3).

The calculated values for the metabolizable energy of fish meal and soybean meal available to fish and the smaller fish gains more energy than the bigger fish when using similar feedstuffs (Table 3). Further, the results indicated that the metabolizable energy of fish meal accounts only for about 68 and 66% of energy intake for groups A and B fishes, respectively. Similarly, in case of soybean meal the ME accounts for about 60 and 58 % of energy intake for groups A and B fishes, respectively.

Table 2: Energy and Cr_2O_3 contents of fish meal, soybean meal and feces for two different sizes of rainbow trout

Sample	Gross energy (kcal kg^{-1})	Chromic oxide (%)
Fish meal	4732	0.035
Feces (group A = 120 g)	2592	0.088
Feces (group B = 220 g)	2645	0.081
Soybean meal	4345	0.026
Feces (group A)	3411	0.066
Feces (group B)	3538	0.063

Table 3: Nutrient digestibility, digestible and metabolizable energy of fish meal and soybean meal with two different sizes of rainbow trout

Fish size	Nutrient digestibility (%)	Digestible energy (kcal kg^{-1})	Metabolizable energy (kcal kg^{-1})
Group A*(120 g)	78.20	3700	3204
Group B*(220 g)	75.90	3591	3110
Group A**	69.15	3004	2601
Group B**	66.50	2889	2502

*: Fish fed fish meal, **: Fish fed soybean meal

Table 4: Comparison of DE and ME values of fish meal and soybean meal for rainbow trout obtained at present study and those described in the earlier study

Sample	Crude protein (%)	DE (Kcal kg^{-1})	ME (Kcal kg^{-1})	Reference
Fish meal tested	62.5	3700	3204*	Present study
		3591	3110**	
Anchory fish meal	65.5	4570	4020	Ozogul *et al.* (2006)
				Raven *et al.* (2006)
	54.5	3450	3100	Glencross *et al.* (2007)
Herring fish meal	72.0	4717	4130	Ozogul *et al.* (2006)
	63.0	3720	3290	Glencross *et al.* (2007)
Menhaden fish meal	61.3	3500	3160	Glencross *et al.* (2007)
Soybean meal tested	41.4	3004	2601*	Present study
		2889	2502**	
Soybean meal	48.0	2900	2510	Glencross *et al.* (2007)
Soybean meal	49.7	2957	2560	Raven *et al.* (2006)
Soybean meal	49.9	2980	2570	Ozogul *et al.* (2006)

*: 120 g fish, **: 220 g fish

Although there are a general agreement between present values with the values described by other researchers (Yusefi, 2000; Lovell, 1998; NRC, 1993) the existing differences could be attributed to a wide variety of factors, among them feedstuffs composition (Wang *et al*., 2006; Glencross *et al*., 2005), namely protein contents (Glencrooss *et al*., 2005; De Silva and Anderson, 1995). Moreover (Jobling, 1994; Talbot, 1990) reported that the differences in composition and amounts of nutrient present in feedstuffs, leads to different levels of digestibility, hence effecting the levels of digestible energy and metabolizable energy available to fish (Wang *et al*., 2006; Glencross *et al*., 2005). For instance, herring fish meal with a protein content of 72% yields a digestible energy content of 4717 kcal kg^{-1}, while the same feedstuff with a protein content of 63% yields to 3720 kcal kg^{-1} digestible energy (Table 4). Similar trends also holds true for soybean meal in which various levels of protein have been reported to yield different levels of DE and ME contents (Azevedo *et al*., 2005). Another important factor which might lead to lower nutrient digestibility in soybean meal is its trypsin inhibitor and if soybean samples subject to poor processing condition, the negative effects of trypsin inhibitor will be more obvious (Glencross *et al*., 2007; Murray *et al*., 2007). The negative effects of trypsin inhibitor in soybean meal have been reported (Poorreza, 2006). It seems that fishes and specially rainbow trout are more sensitive to trypsin inhibitor than other species chickens (Shirmohammad *et al*., 1997; Poorreza, 2006). It is noteworthy to mention that the feedstuff processing (Glencross *et al*., 2007), fish size and species (Raven *et al*., 2006; Azevedo *et al*., 2004) and water temperature (Willoughby, 1999) are also the otherfactors that may influence the available DE and ME to fish for similar food items. This may be the case for differences values obtained for soybean meal. Results indicated that plant sources are less utilize than animal sources in rainbow trout (Shirmohammad *et al*., 1997) and this should be consider when formulating diet for this species. Use of higher levels of plant sources in fish diet should be avoided, due to lower nutrient digestibility of these sources in rainbow trout (Murray *et al*., 2007; Ozogul *et al*., 2006).

Present findings also confirm the effect of fish size on digestibility and DE available to fish. So that, the highest values of digestibility and DE were obtained for 120 g fish, for the both feedstuffs used. The reason for such differences may possibly be due to a more efficient utilization of food and hence a better growth performance in smaller fish (Raven *et al*., 2006; Azevedo *et al*., 2004). Similar size effects were also reported by other workers (Henrichfreise and Pfeffer, 1992; Jobling, 1994).

Regarding the results obtained by Baily and Anavara (2006) and Talbot (1990) and the results of the present study, the point of great importance in all these studies is the method used, which is a decisive factor in measuring nutrient digestibility. Therefore, vast range of values reported in the literature for the similar feedstuffs and for the same species, could stems from the method used.

CONCLUSION

The obtained results in this experiment indicated that, feedstuff type and fish size, influence the digestible energy. Plant sources are less utilized than animal sources. The digestible energy and increasing fish size, reduce feedstuff utilization. Therefore, it is necessary to consider the feedstuff type, fish size and age, in formulating diets for fish.

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