The digestibility of nutrient sources for common carp, Cyprinus carpio Linnaeus

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Abstract

The apparent digestibility of protein, fats, carbohydrate and energy within three feed ingredients (wheat, barley and corn) for common carp, Cyprinus carpio Linneaus, was studied, using chromic oxide as a dietary marker. Each experimental diet consisted of a mixture of the test ingredient and 50% basal diet (containing 50% soybean, 35% wheat meal, 10% soybean oil, plus 5% vitamins, egg yolk, guar and chromic oxide). It was found that in wheat meal the protein had an apparent digestibility of 92%, and the lipid an apparent digestibility of 80%. The apparent digestibility of corn was 81% for protein and 90% for lipid, while for barley the figures were 73% and 67%, respectively. For apparent digestible energy, the figures were 12.39 Kj g-1 for wheat, 6.69 Kj g-1, for barley and 9.32 Kj g-1 for corn.

Introduction

Digestibility is one of the most important aspects in evaluating the suitability of feedstuffs. Studies on the digestibility of nutrients from feedstuffs have revealed differences in energy utilization efficiency between species, due to differences in digestive physiology, thus making species buy species digestibility evaluations necessary.
Chromic oxide is frequently used as an inert reference compound in determining the apparent digestibility of nutrients in fish. Thus, when measuring the digestibility of feeds by indirect methods, the digestibility of feeds by indirect methods, the apparent digestibility of the nutrient component in a diet is calculated from the ratio of the indicator to nutrient in the food and in the faeces.
Energy-yielding nutrients, such as facts or carbohydrates, have been found to lessen the oxidation of dietary proteins for energy. This satisfies the energy requirements of fish, and thus improves the utilization of protein for tissue accretion. The beneficial effects of the incorporation of protein-sparing nutrients have been studied and optimal ratios between protein and energy suggested for many species of fish. A surplus of dietary energy has been found to lead to a high carcass fat content in several species. Carbohydrates and lipids are important as sources of energy and for their ability to 'save' protein. The amount and type of carbohydrate that can be included in fish diets is based on the ability of the fish to digest carbohydrate sources.

As with most vertebrates, lipids are used by many fish as an energy source. The age and weight of the fish and the total lipid content of the diet may also influence digestibility. Numerous studies have evaluated lipid levels in diets for fish and, as witch carbohydrates, utilization varies with species and source.
Plant energy sources, carbohydrates as well as oils, are usually the least expensive form of energy for animals, but their utilization efficiency varies among fish species. Grain sources are poorly digested by carnivorous fish, especially trout, although eels, which are also carnivorous, convert wheat meal quite efficiently. Developed feeds for intensive common carp, and tilapia culture without any animal protein.
The determination of the energy digestibility of ingredients is a perequisite to any attempt to formulate diets by linear programming, which has been in use for many years for catfish and trout. Thus, the purpose of this study was to examine the apparent digestibility of energy of three common feed ingredients which are relatively high in carbohydrates: wheat, barley and corn meal, in common carp.

Materials and methods

Fish

The common carp used in this study were obtained from Kibbutz Kfar Giladi. The size of fish used in this study ranged from 500 to 800 gram. The fish were fed the basal diet for 2 weeks before the start of the experiment, and then experimental diet for 1 week before sampling began. They were fed daily at 08.00 hour, at a rate of 3% of body weight. Samples were taken from the diet itself and from the cloaca of the fish, by means of a canula, 6 hour after feeding, over a period of 3 weeks.

Culture system

The culture system used was a recirculating system, with a constant air supply and temperature (23˚C), and with water flow 20 ml h-1. Fish were maintained individually in aquariums measuring 40x40x80 cm.

Diet formulation

Diets were formulated from ingredients available commercially in Israel. Soybean meal (imported from USA) was the main protein source, making up 25% of the total. Wheat, corn and barley were likewise imported from the USA and ground to meal in the authors laboratory. The diet formulations used and their analysis are given in Table 1. All the diets were fed in pellet form, prepared by a steam pallet press. All additives (egg binder, vitamins and markers) were mixed into the diets prior to pelletting.

Feeding trials and analysis

Five samples were taken from the diet itself, and faeces from the cloaca of the five fish, by means of a canula (8mm external, 6mm internal diameter), inserted to a depth of 0.5cm, 6 hour after feeding. A total of 30 samples of faeces was collected.

Samples were analysed for dry matter, crude protein, crude fat, ash contant and Cr2O3.

Digestibility

The apparent digestibility of proteins, carbohydrates, fats and total energy was measured, using the chromic oxide method described by Brisson (1956) and by Maynard&Loosli (1962), as modified by Hanley (1987). Energy was measured by a bomb caloriemeter.

Nutritive analysis

Diet and feaces were analysed by identical methods: dry matter, by drying at 150˚C for 10 hour (constant weight), ash by incineration at 600˚C for 12 hour, crude protein by the Kjeldahl technique (protein = N x 6.25), and total lipid according to Folch, Lee&Sloane-Stanley (1957). Crude fibre in the diets was analysed by 1010 Extractor (Tecator Co., Sweden) in our laboratory. The carbohydrate content in feed and faeces was subsequently calculated as the difference between dry matter content (100%) and the total sum of protein, fat and ash content in the dry matter. The concentration of the indicator, chromic oxide (Cr2O3), was measured by spectrophotometer. The energy of ingredients and faeces was measured by bomb calorimeter.

Table 1, Ingredients of experimental diets (% dry matter)

	Wheat diet	Barley diet	Corn diet	Basal diet
Barley	-	47.5	-	-
Corn meal	-	-	47.5	-
Wheat meal	65.0	17.5	17.5	35.0
Soybean meal	25.0	25.0	25.0	50.0
Soybean oil	5.0	5.0	5.0	10.0
Vitamin mix	0.5	0.5	0.5	0.5
Egg yolk	2.5	2.5	2.5	2.5
Guar	1.5	1.5	1.5	1.5
Chromium oxide	0.5	0.5	0.5	0.5
Protein	23.27	23.23	23.28	34.19
Lipid	8.53	9.04	8.78	12.74
Crude fibre	1.68	3.86	2.15	4.80
NFE	63.43	59.46	62.25	43.69
Ash	3.09	4.41	3.55	4.58
Chromium oxide	0.365	0.340	0.365	0.436
Energy (Kj g-1)	20.20	20.23	20.27	21.58

Wheat meal contained 14% protein, 1% lipid, 0.2% crude fibre, 85% NFE (Nitrogen-free extract). Barley meal contained 15% protein, 2% lipid, 6.1% crude fibre, 74% NFE. Corn meal contained 10% protein, 4% lipid, 3% crude fibre, 81% NFE.

Calculation

The following formula was used to calculate apparent digestibility:

Apparent digestibility (%) = 100 - [% Cr2O3 in feed / % Cr2O3 in faeces x % nutrient in faeces / % nutrient in feed]

The apparent digestibility of the separate components of the diets was calculated according to:

AD* test diet
AD = AD total diet – (AD basal diet x proportion of basal diet)/proportion of test diet.

(*AD = apparent digestibility)

The signification of difference between results was analysed by Student's t-test.

Results

The results of the analysis of the diets and faeces are given in Tables 2 and 3. The apparent digestibility of various components of the diets is shown in Table 4. The principal difference among the diets was the carbohydrate sources, which were wheat meal, barley meal and corn meal.
The level of carbohydrates in the carbohydrate sources was between 74% and 84% (Table 1), while the levels of protein were low, at 10%-14%. Hence, the carbohydrates were the main source of energy.
The results show that, in the common carp, the protein digestibility of wheat meal (92%) is significantly higher ($P<0.05$) than that of corn meal (81%) and barley meal (72%), which results in a digestible energy in wheat of 12.39 Kj g-1, 6.69 Kj g-1 in barley and 9.32 Kj g-1 in corn (Tables 3 and 4). The difference is because the apparent digestibility of booth protein and carbohydrates in wheat was higher than in the other carbohydrate sources.
The level of oil in the carbohydrate sources was very low, between 1% and 4% (Table 1). The apparent digestibility of oil in wheat meal (80%) and in corn meal (82%) is significantly higher than that of oil in barley meal (67%).

Table 2, Composition of faeces (% dry matter)

	Wheat diet	Barley diet	Corn diet	Basal diet
Protein	13.76	11.91	9.66	29-8.93
Lipid	4.95	3.85	2.36	8.56
Crude fibre	2.01	6.32	5.22	9.65
NFE	74.13	71.07	76.96	42.32
Ash	4.19	6.25	5.12	9.21
Chromium oxide	0.961	0.523	0.679	1.332
Gross Energy (Kj g-1)	18.14	18.10	13.49	18.53

Table 3, Digestibility of dietary components (%)

	Wheat diet	Barley diet	Corn diet	Basal diet
Protein	77.54	77.02	73.48	72.09
Lipid	77.96	76.76	78.75	77.84
Energy	65.98	51.16	58.07	71.68
Carbohydrates	55.35	34.33	22.11	67.22
DE (Kj g-1)	3.31	10.45	11.76	15.57

Table 4, Digestibility of carbonhydrate component (%)

	Wheat	Barley	Corn
Protein	91.89	71.86	80.64
Lipid	79.84	66.70	82.01
Energy	68.09	36.26	50.06
DE (Kj g-1)	12.39	10.45	9.32

Discussion

To obtain optimal digestibility, the nutritional components of fish diets must be studied and formulated separately for each species. The determination of digestibility (Austreng 1978), used in the present study, has been widely used in studies of fish feeds, although various other methods have been developed and used. These include abdominal pressure (Nose 1967) and metabolic chambers and suction (Schmitz, Greuel&Pfeffer 1984). Each method has to be specially adapted to the species in question, on the basic of the composition and solubility in water of the faeces dissolve quickly in water, and hence it is very difficult to extract them without loss of some of the components. For this reason, abdominal canula collection was selected for the collection od faeces in the present study.

However, the use of such a variety of methods in different studies makes the comparison of results a difficult matter. Moreover, the apparent digestibility of a given component is affected by the remaining components of the diet. Other parameters may also affect the comparison of results of different studies: the amount feed in each trial, the age and size of fish, the temperature and quality of the water. Further factors are the percentage of crude fibre and of ash, but these were low enough in the experiments carried out in this study to avoid any significant effect on the results. All in all, these factors are the cause of possible differences between apparent digestibility and true digestibility.

The results of the present study indicate that the apparent digestibility of wheat meal is significantly higher than the of barley meal of corn meal, but it must be pointed out that the composition and proportion of protein and carbohydrate components are not uniform, although the difference is not greater than 10% (table 3). In comparison, the apparent digestibility of two carbohydrate sources (glucose and starch) was 30% in rainbow trout (Bergot 1979). The same effect was found in eels, in which wheat meal led to faster growth than other carbohydrate sources.

The apparent digestibility of carbohydrates in the test diets ranged from 55% down to 22%, a range which broadly supports the finding of Chow et al (1980) that carp can utilize up to 48% of dietary starch. Rainbow trout can utilize significantly less carbohydrate from its diet: only up to 25% (Cowey & Sargent 1979). In the present study, the apparent digestibility of protein in wheat and corn was calculated at 55%-34%, of barely at only 22%, and the apparent digestibility of carbohydrates was 65% in wheat, 26% in oats and 62% in corn.
The percentage of lipid in the carbohydrate sources of the present study was kept low, owing to the difficulty of making pellets of feed with a high lipid content. The literature sets the optimal lipid content for the feeds of carnivorous fist at 10-20% (Cowey & Sargent 1979), although technological development has resulted in diets for salmonids frequently containing more than this. The apparent digestibility of lipids in the present study were relatively high in both wheat meal (80%) and corn meal (82%), but lower in barley meal (67%) (Table 4). The results of another study in this series, currently in press, showed that the apparent digestibility of fish oil was higher than for soy oil, indicating that oil from animal sources is more easily digested by the carp than vegetable oil (Degani, Viola & Yehyda, 1997).
In conclusion, the carp shows preference for animal protein sources of food, such as fish meal. However, since some carbohydrates have to be used in the feed formula for economic reasons, it is worth establishing that wheat and corn meals are good candidates for this purpose.

Probavljivost hranjivih izvora za tovljenog šarana

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Sažetak

Očita probavljivost proteina, masti, ugljikohidrata i energije kod ova tri sastojaka hrane za životinje (pšenica, ječam i kukuruz) za šarana, Cyprinus carpio Linneaus je istraživana pomoću kromske oksidacije kao dijetetskog markera. Svaka eksperimentalna prehrana sastojala se od mješavine test sastojka, te 50% bazalne dijete (koja sadrži 50% soje, 35% pšeničnog obroka, 10% sojinog ulja, plus 5% vitamina, žumanjak, guar i kromski oksid). Utvrđeno je da je u obroku proteina pšenice imao očitu probavljivost od 92%, kod lipida očitu probavljivost od 80%. Očita probavljivost kukuruza je bila 81% za protein i 90% za masti, a za ječam brojke su 73% i 67%, respektivno. Za prividnu probavljivost energije, brojke su 12,39 KJ g-1 za pšenicu 6,69 KJ g-1, za ječam i KJ 9.32 g-1 za kukuruz.

Uvod

Probavljivost je jedan od najvažnijih aspekata u procjeni prikladnosti za krmiva. Studije na probavljivost hranjivih tvari iz krmiva su otkrili razlike u učinkovitosti korištenja energije između vrsta, zbog razlike u fiziologiji probave, čime se određuje vrsta procjene potrebne probavljivosti.
Kromni oksid se često koristi kao inertni referent spoja u određivanju prividnih probavljivost hranjivih tvari kod riba. Dakle, kada se radi mjerenje probavljivosti hrane neizravnim metodama, očita se probavljivost hrane hranjivih komponenti u prehrani. Probavljivost se zračunava iz omjera indikatora nutrijenta u hrani i u stolici (izmetu).
Energetski propustljive hranjive tvari, kao što su to ugljikohidrati, su dokazale da smanjuju oksidaciju prehrambenih proteina za energiju. To zadovoljava energetske potrebe riba, a time i poboljšava iskoristivost proteina za izgradnju tkiva. Blagotvorni učinci uključivanja proteina umjerenim hranjivim tvarima su proučavali i optimalni omjer između bjelančevina i energije predložene za mnoge vrste riba. Višak energije u prehrani je utvrdio da će isti dovesti do visokog postotka masti u nekoliko vrsta. Ugljikohidrati i masti su važni kao izvor energije zbog njihove sposobnost da se "spasi" protein. Količina i vrsta ugljikohidrata koji mogu biti uključeni u dijeti kod riba se temelji na sposobnosti riba za probavljovst izvora ugljikohidrata.
Kao i kod većine kralježnjaka, lipidi se kod većine riba koriste kao izvor energije. Dob i težina ribe i ukupni sadržaj lipida u prehrani također mogu utjecati na probavljivost. Brojne studije su ocijenile razinu lipida u obrocima za ribe, zajedno sa ugljikohidratima, korištenje varira sa vrstama i izvorima. Vrlo često se u vezi ove teme mogu pročitati proturječni podatci.
Biljni izvori energije, kao ugljikohidrati i ulja, su obično najjeftiniji oblik energije za životinje, ali njihova uporaba učinkovitost varira od vrste riba. Izvori žitarica se slabo vare od strane mesožderskih riba, osobito pastrve, jegulje. Ali, isto tako kao i kod pojedinih mesoždera, varenje pšeničnog brašna je prilično učinkovito. One su razvijen izvor energije za intenzivan uzgoj šarana i tilapije bez upotrebe drugih životinjskih izvora za bjelančevine.
Određivanjem energetske probavljivosti sastojaka se na svaki način pokušavaju odrediti i formulirati dijete po linearnom programiranju, koje su dugi niz godina u uporabi za soma i pastrvske vrste. Dakle, svrha ovog rada bila je ispitati očito probavljivost energije od tri zajednička sastojaka hrane koje su relativno bogata sa ugljikohidratima: pšenice, ječma i kukuruznog obroka, u hrani za šarana.

Materijali i metode

Riba

Šarani tovljenici korišteni za ove studije potiču od Kibbutz Kfar Giladi. Veličina ribe korištena u ovoj studiji je bila u rasponu od 500 do 800 grama. Ribe su hranjene sa bazalnom dijetom 2 tjedna prije početka pokusa, a zatim su ribe dobile jednu sedmicu prije pokusa obroke kiji su se upotrebljavali i za vreme pokusa. One su hranjene svakodnevno u 08.00 sati, po stopi od 3 posto tjelesne težine. Uzorci su uzeti iz prehrane i samog izmeta od riba pomoću kanula, 6 sati nakon hranjenja, tijekom razdoblja od 3 tjedna.

Sustav kulture

Sustav kulture je sustav koji se koristi za cirkulaciju zraka u sustavu, sa stalnom temperaturom zraka od (23˚C), a protok vode je bio 20 ml H-1. Ribe su se držale pojedinačno u akvarijumu omjera 40x40x80 cm.

Formulacija dijete

Dijete su formulirane od komercijalno dostupnih sastojaka u Izraelu. Sojina sačma (uvezena iz SAD-a) je bila glavni izvor proteina, koji čine 25 posto od ukupnog broja. Pšenica, kukuruz i ječam su akođer uvezeni iz SAD-a, ovi produkti su bili temelj za obrok u laboratoriji autora. U prehrani su se koristile formulacije i njihova analiza, to je prikazano u tablici 1. Sve dijete su bile ponuđene u obliku paleta, koje su bile pripremljenje za tiskom pare. Svi aditivi (jaje vezivo, vitamini i markeri) su bili u hrani prije peletiranja.

Hranidbeni pokusi i analize

Pet Uzoraka je uzeto iz same prehrane i feakalija iz kloaka od pet riba, pomoću kanula (8mm vanjski, 6mm unutarnji promjer), umetnuta na dubini od 0.5cm, 6 sati nakon hranjenja. Ukupno je prikupljeno 30 uzoraka feakalija. Uzorci su analizirani na suhoj tvari sirovih bjelančevina, sirove masti, pepela i Cr2O3.

Probavljivost

Očita probavljivost proteina, ugljikohidrata, masti i ukupne energije mjerena je metodom kromske oksidacije koju je opisao Brisson (1956) i Maynard i Loosli (1962), koji je promijenio i Hanley (1987). Energija je mjerena sa bombardinarnim kalorije-metrom.

Nutritivna analiza

Dijeta i feakalije su analizirani sa identičnim metodama: suha tvar, sušenjem na 150˚C 10 sati (stalne težine), pepel spaljivanjem na 600˚C 12 sati, sirove bjelančevine od strane Kjeldahl tehnike (protein = N x 6,25) , a ukupni lipidi prema Folch Lee i Sloane-Stanley (1957). Sirova vlakna u prehrani su analizirana sa 1010 izvlačivačem (Tecator Co, Švedska) u našem laboratoriju. Sadržaj ugljikohidrata u hrani i izmetu je naknadno izračunavan kao razlika između suhe tvari (100%) i ukupnog iznosa od proteina, masti i pepela u suhoj tvari.
Koncentracija pokazatelja, kromni oksid (Cr2O3), mjeren je spektrofotometrom. Energija sastojaka i izmet mjerena je bombardinarnim kalorimetrom.

Tablica 1, Sastojci eksperimentalne dijete (% suhe tvari)

	Pšenična d	Ječam d	Kukuruz d	Bazalna d
Ječam	-	47.5	-	-
Kukuruzno brašno	-	-	47.5	-
Pšenično brašno	65.0	17.5	17.5	35.0
Sojino brašno	25.0	25.0	25.0	50.0
Sojino ulje	5.0	5.0	5.0	10.0
Vitamin miks	0.5	0.5	0.5	0.5
Jaje, vezivo	2.5	2.5	2.5	2.5
Guar	1.5	1.5	1.5	1.5
Kromni oksid	0.5	0.5	0.5	0.5
Protein	23.27	23.23	23.28	34.19
Lipidi	8.53	9.04	8.78	12.74
Sirova vlakna	1.68	3.86	2.15	4.80
NFE	63.43	59.46	62.25	43.69
Pepel	3.09	4.41	3.55	4.58
Kromni oksid	0.365	0.340	0.365	0.436
Energija (Kj g-1)	20.20	20.23	20.27	21.58

Pšenica obrok sadrži 14% proteina, 1% masti, 0,2% sirovih vlakna, 85% NFE (dušik-slobodni ekstrakt). Ječam obrok sadrži 15% proteina, 2% masti, 6,1% sirovih vlakna, 74% NFE. Kukuruzni obrok sadrži 10% bjelančevina, 4% masti, 3% sirovih vlakna, 81% NFE.

Proračun

Sljedeća formula je korištena za izračun očite probavljivosti:

Vidljiva probavljivost (%) = 100 - [% Cr_2O_3 u hrani /% Cr_2O_3 u izmetu
X % hranjivih tvari u stolici /% hranjivih tvari u hrani]

Očita probavljivost odvojenim komponentama dijeta je izračunata prema:

AD * ispitivanje prehrane
AD = AD ukupno dijeta - (AD bazalna prehrana x udio bazalne prehrane) / proporcionalni dio test prehrane.

(* = Prividna probavljivost AD)

Označavanje razlike između rezultata analiziran je student t-testom.

Rezultati

Rezultati analize dijete i izmeta su dati u tablicama 2 i 3. Očita probavljivost različitih komponenti prehrane prikazana je u tablici 4. Temeljna razlika među dijetama je izvor ugljikohidrata, to su bili pšenična krupica, ječam, i kukuruzni obrok.
Razina ugljikohidrata u izvorima ugljikohidrata je bila između 74% i 84% (Tablica 1), dok je razina proteina bila niska, od 10% do 14%. Dakle, ugljikohidrati su bili glavni izvor energije.
Rezultati pokazuju da je probavljivost proteina pšeničnog obroka u šaranskoj hrani značajno veća (92%), ($P < 0,05$) nego kod kukuruznog brašna (81%) i ječmenog brašna (72%), što rezultira u probavljivu energiju u pšenice od 12,39 KJ g-1, u ječmu 6,69 KJ g-1 i 9,32 KJ g-1 u kukuruzu (tablice 3 i 4). Razlika je veoma očita jer je probavljivost proteina i ugljikohidrata kod pšenice bila mnogo viša nego kod drugih izvora energije.
Razina ulja u izvorima ugljikohidrata je bila vrlo niska, između 1% i 4% (Tablica 1). Očita probavljivost ulja pšeničnog brašna (80%) i kukuruznog brašna (82%) znatno je viša od probavljivosti kod ječmenog brašna (67%).

Tablica 2, Sastav izmeta (% suhe tvari)

	Pšenična d	Ječam d	Kukuruz d	Bazalna d
Protein	13.76	11.91	9.66	29-8.93
Lipidi	4.95	3.85	2.36	8.56
Sirova vlakna	2.01	6.32	5.22	9.65
NFE	74.13	71.07	76.96	42.32
Pepel	4.19	6.25	5.12	9.21
Kromni oksid	0.961	0.523	0.679	1.332
Bruto Energija (Kj g-1)	18.14	18.10	13.49	18.53

Tablica 3, Probavljivost prehrambenih komponenti (%)

	Pšenična d	Ječam d	Kukuruz d	Bazalna d
Protein	77.54	77.02	73.48	72.09
Lipidi	77.96	76.76	78.75	77.84
Energija	65.98	51.16	58.07	71.68
Ugljikohidrati	55.35	34.33	22.11	67.22
DE (Kj g-1)	3.31	10.45	11.76	15.57

Tablica 4, Probavljivost komponenti ugljikohidrata (%)

	Pšenica	Ječam	Kukuruz
Protein	91.89	71.86	80.64
Lipidi	79.84	66.70	82.01
Energija	68.09	36.26	50.06

DE (Kj g-1)	12.39	10.45	9.32

Diskusija

Da biste dobili optimalnu probavljivost i njihove hranidbene komponente riblja dijeta mora biti studirana i formulirana posebno za svaku vrstu nutrijenata. Određivanje probavljivosti (Austreng 1978), korištena u ovom istraživanju se naširoko koristi u istraživanjima riblje hrane, i ako su u međuvremenu razvijene i korištene i druge metode. To uključuje i studiju pritisak u trbuhu (Nos 1967) kao i metaboličke prostorije i usisavanje hrane (Schmitz, Greuel & Pfeffer 1984). Svaka metoda mora biti posebno prilagođena vrsti po pitanju, na temelju sastava i topivosti u vodi, da li se izmet brzo otopi u vodi, te je stoga vrlo teško izvući rezulate bez gubitka neke od komponenti. Iz tog razloga je bila iazbrana metoda kanula kolekcije za prikupljanje izmeta u ovom istraživanju.
Međutim, uporaba takvih različitih metoda u različitim studijama čini usporedbu rezultata vrlo teškom. Štoviše, očita probavljivost za određenu komponentu pod utjecajem ostalih sastojaka u prehrani. I drugi parametri mogu utjecati na usporedbu rezultata različitih istraživanja: količina hrane u svakoj raspravi, dob i veličina ribe, temperatura i kvaliteta vode. Ostali faktori su postotak sirovih vlakana i pepela, ali oni su bili dovoljno niski u eksperimenata provedenih u ovom istraživanju kako bi se izbjegao značajaniji utjecaj na rezultate. Sve u svemu, ovi faktori su uzrok mogućih razlika između prividne probavljivosti i stvarne probavljivosti.
Rezultati ovog istraživanja ukazuju na to da je očita probavljivost pšeničnog brašna znatno viša od ječmenog brašna i od kukuruznog brašna. Ali, ovde se mora naglasiti da sastav i omjer proteina i ugljikohidrata komponenata nisu jedinstveni, iako ta razlika nije veća od 10% (tablica 3). Za usporedbu, očita probavljivost dva izvora ugljikohidrata (glukoze i škroba) je bila 30% u kalifornijske pastrve (Bergot 1979). Isti učinak je pronađena i kod jegulje, pšenično brašno je dovelo do bržeg rasta od drugih izvora ugljikohidrata.
Očita probavljivost ugljikohidrata u prehrani testa je u rasponu od 55% do 22%, raspon koji uglavnom podržava nalaz Chow et al (1980) da šaran može iskoristiti do 48% prehrane škroba. Kalifornijska pastrva može iskoristiti znatno manje ugljikohidrata iz prehrane: samo do 25% (Cowey Sargent & 1979). U ovoj studiji, očita probavljivost proteina pšenice i kukuruza izračunat je na 55% i 34%, od jedva na samo 22%, a očita probavljivost ugljikohidrata 65% u pšenice, 26% u zobi i 62% u kukuruza.
Postotak lipida u izvorima za ugljikohidrate je u ovoj studije nizak, zbog poteškoća u izradi paleta sa visokim sadržajem lipida. U literaturi se spominje optimalni sadržaj lipida u hrani za mesoždere od 10% do 20% (Cowey & Sargent 1979). Tehnološki razvoj je u međuvremenu rezultirao dijete za salmonoide koje vrlo često sadrže više od toga. Očita probavljivost lipida je u ovom istraživanju bila relativno visoka u oba brašna, kod pšeničnog brašna (80%) i kukuruznog brašna (82%), ali manje kod ječmenog brašna (67%) (Tablica 4). Rezultati drugog istraživanja u ovoj seriji, trenutno u tisku, su pokazala da je prividna probavljivost ribljeg ulja veća nego sojinog ulja, što ukazuje da se ulje iz životinjskih izvora lakše probavlja kod šarana od biljnog ulja (Degani, Viola & Yehyda , 1997).
U zaključku, šaran pokazuje sklonost za izvore proteina na životinjskoj bazi, kao što su su to recimo riblja brašna. Međutim, budući da se neki ugljikohidrati moraju

koristiti u hrani iz ekonomskih razloga, to vrijedno utvrđuje da su pšenično i kukuruzno brašno dobri kandidati za tu svrhu.

Prevod i obrada: Darko Županić (CEZAR) 2012

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