ISSN 2229-5518

The use of Coconut (*Cocos nucifera*) oil as an Alternative Source of Energy in the Diets of African Mudcatfish (*Clarias gariepinus* - Burchell, 1822) Juveniles

*Hammed A.M, Amosu A.O, Fashina-Bombata H.A, Ajepe R.G, Olufowobi M.T.

Abstract— A twelve week investigation into the effects of feeding substituted palm oil (PMO) with coconut oil (CNO) as an alternative source of energy, on the growth performance and nutrient utilization of *Clarias gariepinus* juveniles was conducted. Six (6) isonitrogenous 40% crude protein diets were formulated where CNO replaced PMO at 100%, 80%, 60%, 40%, 20% and 0% inclusions and labelled diets 1,2,3,4,5 and 6 respectively. Juveniles of *C. gariepinus* (40.39±2.98g) stocked at 20 fish/50lts plastic tanks in triplicate, were fed twice daily to satiation with weight changes recorded weekly. Samples of experimental diets and fish carcass were analyzed for proximate composition, while growth performance and quality of diets were evaluated. Fish fed diet 4 (containing 60% palm oil, 40% coconut oil) inclusion had the highest mean weight 203.36±2.27g and the best food conversion ratio of 1.44 ±0.34g after the twelve weeks of study. There was significant differences (P< 0.05) in the percentage weight gain between fish fed diet 1 (333.28±1.26g) and fish fed diet 4 (401.75±10.9g). No significant difference (P>0.05) was recorded in protein intake (PI) between fish fed diets 2, 3 and 4 while significant difference (P< 0.05) was recorded in the protein efficiency ratio of fish fed diet 3 (3.05±0.18) and diet 4 (2.50±0.10). Therefore, for better growth, a 40% partial replacement of PMO with CNO as dietary lipid in diet of African mud catfish (*Clarias gariepinus*) juveniles as alternative source of energy is recommended.

Index Terms— *Clarias gariepinus*, diet, coconut oil, palm oil, growth rates, nutrient utilization.

INTRODUCTION

The consumption and demand for fish as a cheap source of protein is on the increase in Nigeria, not only because of the level of the poverty but also because of its nutritional value. The vast majority of the fish supplies in most cases are from import and a small quantity from the rivers in the country. Fish require high-quality nutritional balanced diet for growth and attainment of market size within the shortest possible time. Thus, local production of fish feed is very crucial to the development and sustainability of aquaculture in rural areas. This is expected to bridge the already existing wide gap between fish demand and supply in Africa, especially in Nigeria.

Lipids serve as important source of dietary energy for all fish and to a greater extent for marine and cold water fish which have limited ability to utilize dietary carbohydrate for energy [1]. Studies have shown that providing energy using dietary lipids minimizes the use of protein which is more expensive as energy source [2]. The fatty acid composition of the dietary lipid has a significant influence on the tissue fatty acid composition of the fish [3] [4]. Although, increasing dietary lipids can help reduce the high costs of diets by partially sparing protein in the feed, problems such as excessive fat deposition in the liver can affect fish health and reduce market quality of fish [5]. Despite this fact, fat-deficient diets, on the other hand, may result in growth retardation and physiological disorders. It is therefore important to get the proper lipid-energy ratio in diets for the most economical production of fish. Although dietary lipid concentration of up to 20% have been observed to give optimum results in

- *Corresponding Author - Hammed, AM(PhD) is a Lecturer in Aquaculture & Fish Nutrition in the Department of Fisheries, Faculty of Science, Lagos State University, P.O.Box 0001, LASU Post Office, Ojo, Lagos, Nigeria. E-mail: ayofe.hammed@lasu.edu.ng.+2348023431250
- Amosu, AO is currently pursuing PhD degree program in Seaweed Mariculture , Department of Biodiversity & Conservation Biology, Faculty of Natural Science, University of the Western Cape, Privat Bag X17, Bellville, 7535.Cape Town, South Africa. E-mail: aamosu@uwc.ac.za
- Fashina-Bombata, HA is a Professor of Fish Nutrition in the Department of Fisheries, Faculty of Science, Lagos State University, P.O.Box 0001, LASU Post Office, Ojo, Lagos, Nigeria.
- Ajepe, RG is a Chief Technologist in the Department of Fisheries, Faculty of Science, Lagos State University, P.O.Box 0001, LASU Post Office, Ojo, Lagos, Nigeria.
- Olufowobi, MT is a B.Sc. (Hons) student in the Department of Fisheries, Faculty of Science, Lagos State University, Lagos State University, P.O.Box 0001, LASU Post Office, Ojo, Lagos, Nigeria.

some species [6] [7] [8], no definite percentage of dietary lipids can be given for fish diets without considering the type of lipid as well as the protein and energy content of the diet.

Coconuts (*Cocos nucifera*, family *Arecaceae*) oil could be a kind of dietary lipids in fish feed and nutrition due to its fatty acid composition [9]. According to research it contains 60-70% fatty acids, 4-10% water, and has a protein of < 10% and non-sugar carbohydrate < 20%) [9]. It is highly saturated (about 90%) and the majority of coconut oil is medium chain triglycerides (65%) [9]. The biochemical composition of coconut oil are as follows: Caprylic acid at 8%, Capric acid at 7%, Lauric acid (49%), Myristic acid (17.5-18%), Palmitic acid (8-9%), Stearic acid (2-3%), Oleic acid (5-6%), Linoleic acid (1.8-2%): other components in coconut oils but not fatty acids includes: vitamin E, vitamin C, sterols and squalene [9] [10] [11] [12].

There is information on copra meal and other dietary fatty acids as source of energy and their level of inclusion in diets of farmed fish species has revealed significant benefit in physiology of fishes [13] [14]. Presently little is known and this study form current baseline research to investigate the growth response and the effects of feeding substituted palm oil (PMO) with coconut oil (CNO) as an alternative source of energy, on the growth performance and nutrient utilization of *Clarias gariepinus* (Burchell, 1822) juveniles.

MATERIALS AND METHODS

Experimental Design

Eighteen circular plastic tanks of about ≈50 litres were used to carry out the experiment at the Lagos State University hatchery. A total of 380 juveniles were hatchery reared fish at the Hatchery unit of the department of Fisheries, Lagos State University in Ojo, Lagos State. The fish were acclimatized for 24hours and then stocked at 20 fish/ tank for experimentation.

Fish Feed Formulation and Preparation

Six (6) different feeds were formulated (Table 1) based on combination of animal and plant protein sources. The formulated feeds differed in the percentage composition of coconut oil and palm oil. Diet preparation was based on descriptions of [15] as reported by [16] [17] [18].

Feeding trials of the Juveniles

The fish were fed at 4% body weight. Ration was fed thrice (8am, 12noon and 4pm) daily for twelve (12) weeks while body weight was measured fortnightly. The body weight measurements to the nearest 0.01 g using a sensitive weighing balance (Electronic Precision Balance Model EJB-KD-3000g, Endel Global Weighing Company).

Determination of Growth and Nutrient Utilization

Growth indices such as weight gain (WG), percentage weight gain (%WG), specific growth rate (SGR), feed conversion ratio (FCR), gross feed conversion ratio (GFCR), protein intake (PI), protein efficiency ratio (PER) and survival rates were used to evaluate the experimental diets.

Water Quality Management

Following the description of [19] using a conductivity meter kit (model KTO, HQ, 40D PHC 101-LD 101-01 by Hach Company Ltd, USA, temperature, dissolved oxygen concentration and pH were measured on a weekly basis. Temperature ranged between 27-29^{o}C; dissolved oxygen concentration 5.0 – 6.7mg^{-1} and pH 6.2 - 7.1.

Chemical Evaluation of Experimental fish

Samples of experimental diets and fish were analyzed for their proximate composition according to the methods [20]. A sample of 2.5 g was taken in Kjeldahl flask to which nitric acid and perchloric acid was added at the ratio of 2.5:1. The sample was boiled very gently; adjusting flame as necessary, until the solution is colorless and dense white fumes appeared. Then it was cooled slightly and the volume was made up to 250 ml. This sample was directly used to estimate the chromium content by flame ionization Atomic Absorption Spectrophotometer (AAS 4129, Electronics Corporation of India Limited) using chromium cathode lamp (357.9 nm).

RESULTS AND DISCUSSIONS

The use of vegetable oils in the production of aquafeed has been a welcome development for the aquaculture industries over decades [21]. Recent studies revealed that substantial use of vegetable oils as energy sources in fish diets have yielded positive growth response in fish [22] [23].

The study shows an increase in the weekly fish weight changes (Table 2) in all diets with the fish fed diet 4 (containing 60% PMO, 40% CNO) having the highest body weight (162.80±7.75g) and significantly different ($p<0.05$) from fish fed diet 3 (134.60±12.64g).

The highest percentage weight gain (401.75±10.9) was observed and recorded on diet 4 containing (60% PMO, 40% CNO) and the lowest percentage weight gain (333.30±1.26) was recorded on diet 1 containing (0% PMO, 100% CNO) at the end of the experiment as shown in table 2.

The highest food conversion ratio (1.96±0.12) was observed and recorded in diet 3 containing (40% PMO, 60% CNO) and the lowest food conversion ratio (1.44±0.34) recorded in diet 4 containing (60% PMO, 40% CNO) at the end of the experiment. This shows that fishes fed on diet 4 converted the diet well with good performance. The improvement in FCR with increasing high lipid level in tested feeds is in agreement with previous studies [24].

The highest mean GFCE (80.65±1.50) was observed in diet 4 and was significantly different from the value obtained from fish fed diet 1 (67.57±4.26) (Figure 1).

The highest weekly specific growth rate (0.015±0.026) was observed in diet 5 containing (80% PMO and 20% CNO) at the end of the experiment. The lowest specific growth rate (0.007±0.0002) was recorded in diet 3 containing (40% PMO, 60% CNO) and this indicates an improvement in growth with time.

The decrease in protein efficiency ratio PER with increasing high lipid level in PMO and CNO in this study agrees with earlier studies [25] who did not observe any protein sparing effect of lipid when they fed European Sea bass on graded levels of dietary lipid. Research findings opined that there was an influence of a non-protein source of energy (lipid or carbohydrate) on the nitrogen retention and that dietary lipid may also influence the growth performance and protein utilization [26]. This could imply no palatability problem and that their utilizations were adequate, which is similar to the work on the utilization of coconut and palm oil in catfish diet [23].

The 100% inclusion levels in of the various oils used in the present study appear to be within acceptable limits that ensures balances in fatty acids components of feed. This result may however be responsible for the high level performance of fish under all treatments which is in line with the reports of [27] [28] and is responsible for overall high survival rates, which was higher than values (85%) recorded for sharpsnout sea bream fed graded levels of dietary soybean oil diets in another study [29]. Marginally superior PER and FCR exhibited by fish fed on diet 4 (280.69±0.10) and (1.24±0.34) respectively, as reported in table 2 compared to other diets could be as a result of its superior fatty acid composition as vegetable oils are known to have a reduced amount in EPA and DHA [30] . It could be the high quality dietary fatty acid composition in palm oil over coconut oil.

Consequently, fish carcass quality (Table 4) was similar for diet 3 and fish fed diet 4, especially in terms of crude protein and lipid value and closely related to the values of other vegetable sources except for few differences. This observation is similar to those made on other fish species including Atlantic salmon [31] [32].

CONCLUSION

This experiment reveals that both palm oil and coconut oil could be used as energy sources in the diets of juvenile African mud catfish at between 60% PMO/40% CNO to 100% PMO/0% CNO inclusions without any problem to the fish growth and health. However, the best growth performance was noted to be at 60% PMO/40% CNO inclusion thus it is recommended.

ACKNOWLEDGEMENTS

We thank the management and staff of hatchery unit in the department of Fisheries at the Lagos State University, Ojo, Lagos, Nigeria. You are all appreciated for providing hatchery facility and other research equipment used during this experiment.

REFERENCES

[1] S.J, Walton, “Effects of protein intake on metabolisable and net energy values of fish diets. 95-177, 1986.
[2] R.P, Wilson, “Optimum dietary protein to energy

ratio for channel fish fingerling *Ictalurus punctatus. Journal of Nutrition* 106: 138-139, 1982.

[3] R.J, Henderson and C.O, Tocher, "Energy and protein utilization in rainbow trout, (*Salmo gairdneiri). World nutrition diet review* 61: 132-134, 1987.

[4] B.I, Sargent, A.M, Ey-Sayed and D.L, Garling, "Carbohydrate to lipid ratio for *Tilapia zillii* fingerlings. *Aquaculture,* 73: 157-163, 1989

[5] S, Craig, "Understanding Fish Nutrition, Feeds, and Feeding. Virginia Cooperative Extension. Virginia State University. Virginia State, Petersburg, 2009.

[6] D.L, Lee and G.B, Putnam, G.B, "The response of rainbow trout to varying protein/energy ratios in a test diet. *Journal of Nutrition, 103*: 916 – 922, 1973.

[7] R.E, Adron, A, Mangalik and R.T, Lovell, "Dietary energy requirement of channel catfish. *Ph.D Dissertation*. Auburn university, Auburn, Alabama. 125, 1976.

[8] T, Takeuchi, T, Watanabe and C, Ogino, "Optimum ratio of dietary energy to protein for carp. *Bull. Japan Social Science Fisheries*. 45: 983-987, 1979.

[9] M, DebMandal and S, Mandal, "Coconut (Cocos nucifera L.: Arecaceae): in health promotion and disease prevention. *Asian Pac J Trop Med*., 2011.

[10] C.L, Burnett, *et al*, "Final report on the safety assessment of Cocos nucifera (coconut) oil and related ingredients. *Int J Toxicol*, 2011.

[11] M.L, Assunção, *et al*, "Effects of dietary coconut oil on the biochemical and anthropometric profiles of women presenting abdominal obesity. *Lipids*, 2009.

[12] A.L, Loki and T, Rajamohan, "Hepatoprotective and antioxidant effect of tender coconut water on carbon tetrachloride induced liver injury in rats. *Indian J Biochem Biophys,* 2003.

[13] D.J, McKenzie, "Effects of dietary fatty acids on the respiratory and cardiovascular physiology of fish, Comparative Biochemistry and Physiology Part A 128, 607- 621, 2001.

[14] V, Heuzé, D, Sauvant, G., Tran and D, Bastianelli, "*Copra meal and coconut by-products*. Feedipedia.org. A programme by INRA, CIRAD, AFZ and FAO. http://www.feedipedia.org/node/46 *Last updated on December* 20, 23:37, 2013.

[15] D.L, Garling Jr, and R.P, Wilson, "Effect of dietary carbohydrate-to-lipid ratios on growth and body composition of fingerling channel catfish. *Progressive Fish Culturist, 39*: 43-47, 1977.

[16] A.M, Hammed, H.A, Fashina-Bombata and R.A, Olowu, "Growth response and survival rate of *Clarias gariepinus* fingerlings exposed to varying metal concentrations. *Pacific Journal of Science and Technology* 14(1): 430-438, 2013a.

[17] A.M, Hammed, A.O, Amosu and H.A, Fashina-Bombata, "Effect of partial and total replacement of Soybean meal with Pigeon pea (*Cajanus cajan*) as alternative plant protein source in the diet of juveniles African Mud catfish (*Clarias gariepinus* (Burchell, 1822). *International Journal of Food Technology Photon 105*, 139-145, 2013b.

[18] H.A, Fashina-Bombata and A.M, Hammed, "Determination of Nutrient Requirements of an Ecotype Cichlid of Epe Lagoon, Southwest Nigeria. *Global J. Agric. Sci.* 9(2):57-61, 2010.

[19] C.E, Boyd, *"Water Quality for Pond Aquaculture'*. Research and Development Series No. 43. International Centre for Aquaculture and aquatic Environments, Alabama, USA, 43, 1998.

[20] A.O.A.C. (Association of Official Analytical Chemists), "Official Methods of Analysis. 16th Edition. P. Cuniff (ed.). AOAC International Arlington Virginia, U.S.A. 1995.

[21] A.O, Sotolu, "Feed utilization and biochemical characteristics of Clarias *gariepinus (Burchell, 1822)* fingerlings fed diet containing fish oil and vegetable oil as total replacements. *World Journal of Fish and Marine Sciences,* 2(2): 93-98, 2010.

[22] T.O, Babalola and M. A, Adebayo, "Effects of dietary lipid level on growth Performance and feed utilization of *Heterobranchus longifilis* fingerlings. *Journal of Fisheries International*, 21: 60-64, 2007.

[23] Z.A, Aderolu, and O.A, Akinremi, "Dietary effects of coconut oil and peanut oil in improving biochemical characteristics of *Clarias gariepinus* juvenile. *Turkish Journal of Fish and Aquatic Sciences,* 9: 105-110, 2009.

[24] Z, Pie, S, Xie, W, Lei, X, Zhu, and Y, Yang, "Comparative study on the effect of dietary lipid level on growth and feed utilization for Gibel carp (Carassius auratus gibelio) and Chinese long snout catfish (*Leiocassius logirostrisi* Gunther). *Aquaculture Nutrition,* 10(4): 209-216, 2004.

[25] H, Peres and A, Oliva-Teles, "Effect of dietary lipid level on growth performance and feed utili-

ISSN 2229-5518
zation by European sea bass juveniles (*Dicentrarchus labrax*). Aquaculture 179, 325–334, 1999.

[26] S.J, Kaushik and F, Me´dale, "Energy requirements, utilization and dietary supply to salmonids. Aquaculture. 124, 81–97, 1994.

[27] K.G, Fitzsimmons, G. Dickenson, C. Brand and J. Davis, "Effects of reducing dietary lipid levels on growth and body composition of hybrid tilapia in an intensive recirculating-water system. *Progressive Fish Culturist*, *59*: 293-296, 1997.

[28] NRC (National Research Council), "Nutrient Requirements of Fish. National Academy Press, Washington, DC, 114, 1993.

[29] M.A, Piedecausa, M.J. Mazon, B, Garcia-Garcia and M.D. Hernandez, "Effects of total replacement of fish oil by vegetable oils in the diets of Sharpsnout seabream (*Diplodus puntazzo*), Aquaculture. Journal of aquaculture,.09.39, 2007.

[30] S.J, Kaushik, "Fish oil replacement in aquafeeds. *Aqua Feeds Formulation and Beyond*, *1*: 3-6, 2004.

[31] D, Menoyo, C.J, Lopez-Bote, J.M, Baustita and A, Obach, " Growth, digestibility and fatty acid utilization in large Atlantic salmon (*Salmo salar* L.) fed varying levels of n-3 and saturated fatty acids. *Aquaculture*, *225*: 295-307, 2003.

[32] W.K, Ng, Y, Wang, and K.H, Yuen, "Replacement of dietary fish oil with palm fatty acid distillate elevates tocopherol and tocotrienol concentrations and increases oxidative stability in certain haematological parameters in Siluroid catfish muscles of African catfish, *Clarias gariepinus*. *Aquaculture, 233*: 423-437, 2004.

ISSN 2229-5518

Table 1: Gross composition of the experimental diets with different oil levels fed to African Catfish (*Clarias gariepinus*) juveniles

Ingredients (g/DM)	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
	0% PMO, 100% CNO	20% PMO, 80% CNO	40% PMO, 60% CNO	60% PMO, 40% CNO	80% PMO, 20% CNO	100% PMO, 0% CNO
Fish meal	37.17	37.17	37.17	37.17	37.17	37.17
Soybean meal	37.17	37.17	37.17	37.17	37.17	37.17
White maize	19.17	19.17	19.17	19.17	19.17	19.17
Palm oil	0	1	2	3	4	5
Coconut oil	5	4	3	2	1	0
Ca_2So_4	0.5	0.5	0.5	0.5	0.5	0.5
Premix	1	1	1	1	1	1
Total	**100**	**100**	**100**	**100**	**100**	**100**

Table 2: Cumulative growth performance of *C. gariepinus* juveniles fed diets with different levels of coconut and palm oil inclusions

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
	0% PMO, 100% CNO	20% PMO, 80% CNO	40% PMO, 60% CNO	60% PMO, 40% CNO	80% PMO, 20% CNO	100% PMO, 0% CNO
Initial Weight(g)	40.39 ± 2.98^{a}	40.06 ± 3.18^{a}	40.10 ± 3.66^{a}	40.53 ± 3.79^{a}	40.97 ± 2.14^{a}	40.64 ± 1.53^{a}
Final Weight(g)	175 ± 2.80^{a}	185 ± 2.91^{b}	196.60 ± 2.66^{c}	203.36 ± 2.27^{d}	185 ± 2.78^{b}	185 ± 2.69^{b}
Weight gain(g)	134.60 ± 12.64^{a}	144.40 ± 7.59^{a}	156.50 ± 6.50^{ab}	162.80 ± 7.75^{b}	144 ± 7.25^{a}	144.40 ± 7.95^{a}
%Weight gain	333.28 ± 1.26^{a}	361.81 ± 11.24^{b}	390.27 ± 10.4^{c}	401.75 ± 10.9^{c}	351.55 ± 10.7^{b}	355.22 ± 10.7^{b}
SGR	0.008 ± 0.001^{a}	0.008 ± 0.002^{a}	0.007 ± 0.002^{a}	0.008 ± 0.001^{a}	0.015 ± 0.026^{b}	0.012 ± 0.010^{b}
FCR	1.84 ± 0.29^{a}	1.88 ± 0.20^{a}	1.96 ± 0.12^{a}	1.44 ± 0.34^{b}	1.80 ± 0.19^{a}	1.78 ± 0.26^{a}
GFCE	67.57 ± 4.26^{a}	71.94 ± 1.12^{a}	75.19 ± 2.26^{a}	80.65 ± 1.50^{b}	71.43 ± 1.36^{a}	72.46 ± 1.75^{a}
PI	0.58 ± 0.42^{a}	0.57 ± 0.52^{a}	0.57 ± 0.22^{a}	0.58 ± 0.46^{a}	0.59 ± 0.30^{a}	0.58 ± 0.78^{a}
PER	2.70 ± 0.08^{a}	2.83 ± 0.12^{a}	3.05 ± 0.18^{b}	2.50 ± 0.10^{c}	2.90 ± 0.15^{a}	2.81 ± 0.14^{a}

Figures in the same horizontal row having the same superscript are not significantly different ($p > 0.05$).

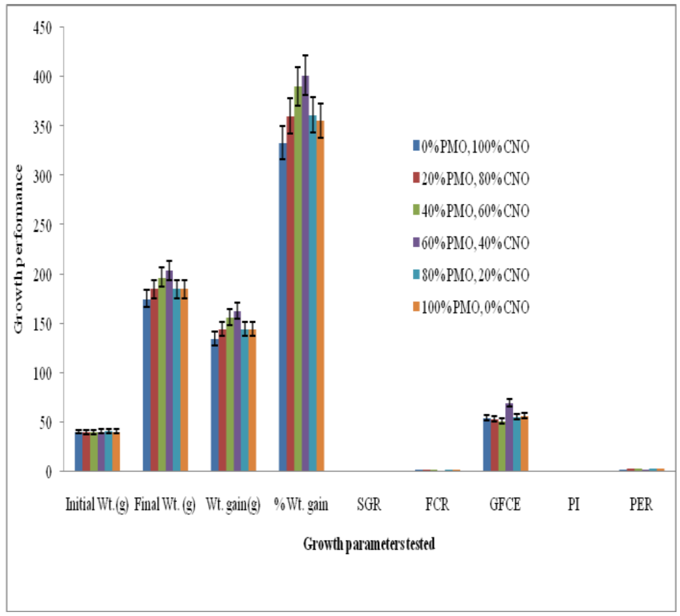

Figure 1: Effect of different diet compositions on the growth rate and nutrient utilization of juvenile *C. gariepinus*

Table 3: Proximate analysis of the experimental feeds of *C. gariepinus* juveniles fed diets with different levels of coconut and palm oil inclusions

Feed composition	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
	0% PMO, 100% CNO	20% PMO, 80% CNO	40% PMO, 60% CNO	60% PMO, 40% CNO	80% PMO, 20% CNO	100% PMO, 0% CNO
Crude protein %	33.2	35.6	33.7	37.5	34.3	34.7
Crude fibre %	7.2	8.9	9.6	8.7	10.1	9.4
Ash %	10.4	8.8	9.2	7.1	8.9	9.1
Moisture %	8.1	8.3	8.0	6.6	8.3	8.4
Crude lipid %	6.2	7.1	7.1	7.6	7.5	7.3
NFE	34.9	31.3	32.4	32.5	30.9	31.1

Table 4: Proximate composition of experimental fish samples fed diets with different levels of coconut and palm oil inclusions

Body composition	Initial body composition	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
		0% PMO, 100% CNO	20% PMO, 80% CNO	40% PMO, 60% CNO	60% PMO, 40% CNO	80% PMO, 20% CNO	100% PMO, 0% CNO
Crude protein	66.15	67.67	69.45	68.48	72.59	71.1	71.3
Ash %	14.30	13.90	12.10	14.3	11.70	13.7	13.9
Crude fibre %	1.65	1.43	1.45	1.62	1.41	1.53	1.57
Moisture %	13.30	12.70	12.80	11.5	10.20	11.5	12.7
Crude lipid %	4.60	4.30	4.20	4.1	4.10	4.2	4.3