AACL BIOFLUX

Aquaculture, Aquarium, Conservation & Legislation
International Journal of the Bioflux Society

The effect of supplementary feeds quality on growth performance and production of common carp (*Cyprinus carpio* L.) at one summer of age, in ponds aquaculture systems

Mihai C. Mocanu, Tiberiu Vanghelie, Petronela G. Sandu, Lorena Dediu, Lucian Oprea

"Dunărea de Jos" University of Galati, Faculty of Food Science and Engineering, Galati, Romania. Corresponding author: L. Oprea, lucian.oprea@ugal.ro

Abstract. The paper presents some aspects regarding the influence of food quality on common carp (*Cyprinus carpio*) fry and juveniles, fed with different extruded and expanded pellets. The experiment covered 120 day-period, and was carried out in four small breeding units, type pond, 5000 m^2 each. Two kind of variants were compared, with repetition: V1, using pellets with 48% and 35% crude protein and V2 using pellets with 48% and 30% crude protein, respectively. The stocking density was of 30000 fish ha^{-1} (30 kg ha^{-1}), in each variant. The same feed quantity and feeding level was used in every unit. At the end of the experiment the technological indicators revealed the following: the mean biomass gain was 3825 kg ha^{-1} in V1, compared with 3510 kg ha^{-1} in V2. This was correlated with the quality of pellets used, more favorable in V1; the mean growth rate of fish biomass (GR) varied in a similar way, from 31.88 kg day^{-1} in V1 to 29.25 kg day^{-1} in V2. The differences were also influenced by the pellets quality; the mean specific growth rate of fish biomass (SGR) was 4.05% day^{-1} in V1 and 3.98% day^{-1} in V2. This shows that the fish growth was very good, in both variants; the mean feed conversion ratio (FCR) was 1.26 kg of pellets per kg weight gain in V1 and 1.38 kg of pellets per kg weight gain in V2. The FCR values are very good for fishponds system. The quality of supplementary feeds positively influenced the FCR final value. The fish breeding parameters showed that variation in feed quality, in term of crude protein end gross energy, positively influenced the growth performance of common carp fry and juveniles, fish biomass gain and feed conversion.

Key Words: common carp, fishponds, extruded/expanded pellets, growth rate, feed conversion.

Introduction. Fisheries are an important segment of the global food system, presently representing approximately 20% of protein intake. Aquaculture currently is the source of half of world fisheries production for human consumption and around 8-9% of the animal protein intake (Boyd 2015; FAO 2012).

The common carp (*Cyprinus carpio*) is the third most important farmed freshwater species in the world and the most important in Eastern Europe (Ljubojevic et al 2015). Semi-intensive carp culture is an ancient popular practice in Romania, representing the most applied aquaculture technology. The main reason of carp production intensification is represented by cereals replacement with pelleted and extruded feeds (Markovic 2010, cited by Ciric et al 2015).

In 1988, the total inland fish production of Romania was about 60,000 metric tons, being the second in Europe (FAO 1995). More than 90% of this production was realized in semi-intensive culture systems, based on common carp and Chinese carp species. After 1989, the freshwater fish production of Romania dramatically decreased to about 10,000-15,000 metric tons per year (FAO 2015).

Following the spectacular development of the aquaculture sector numerous scientific studies have been addressed to nutrition research and to development of specific diets for aquatic organisms. In aquaculture industrial systems the high yields could not be obtain unless the use of formulated feed, supplementary feeding being addressed not only for maintenance but mainly for production purposes (Oprea & Georgescu 2000).

In aquaculture, the efficiency of granulated feed utilization depends largely on formulation and preparation technology and thereof, on the combination and concentration of raw feed ingredients in mixtures that meet nutritional requirements of cultured species. Because protein is the most expensive part of fish feed, especially if it originates from marine fish meal, it is important to accurately determine the protein requirements for each species and size of cultured fish (Hepher 1988; Lovell 1987; Horvath et al 1992).

The aim of this study was to elucidate the effects of supplementary feeds, extruded and expanded pellets with 48%, 30% and 35% crude protein, on common carp growth performance and feed intake.

Material and Method

Study site and pond preparation. The 4 months experiment was conducted between June and October 2014 in 4 ponds, located at the Giurgiu/Bila Fish Farming of Alexander Park Company. All ponds were rectangular in shape with a size of 5000 m^2 and an average depth of 1.2 m. Prior to the experiment, ponds were drained, renovated, small fishes (*Leucaspius delineatus, Pseudorasbora parva, Gobio gobio, Carrasius gibelio, Perca fluviatilis, Rutilus rutilus, Scardinius erythrophthalmus* etc.) and macro vegetation (*Phragmites communis, Tipha latifolia*) were eradicated.

Pond fertilization is an important component of semi-intensive to intensive aquaculture pond management that supports successful production of the culture organism (Green 2015). In order to increase the natural food growth and availability, were used 100 kg ha^{-1} $CaOCl_2$ (bleach), 1000 kg ha^{-1} $Ca(OH)_2$ (lime), 100 kg ha^{-1} NH_4NO_3 (ammonium nitrate) and 3000 kg ha^{-1} manure.

Fish stocking and feed management. All ponds were stocked with 30000 common carp fry per ha, with 1 g $fish^{-1}$ as individual body weight. Two experimental variants were used, the factor being the crude protein of expanded pellets: 30% in V1 and 35% in V2. Before using these diets, in the first 30 days, in V1 and V2, another extruded fodder with 48% crude protein was used. All treatments were executed in duplicate.

As feed ingredients, the three kind of diets contained fish meal, soybean meal, cereals products, yeast, minerals and vitamin premix. All extruded and expanded pellets were imported by Kralex Food Solutions Technology Co., Romania from ECO FEED D.O.O., Serbia (Table 1).

Table 1

Chemical composition of extruded and expanded pellets

Nutrients	*UM*	*FeedEx 48/10*	*FeedEx 35/09*	*FeedEx C 30/07 Profi*
Crude protein	%	48.0	35.0	30.0
Crude fat	%	10.0	8.0	7.0
Ash	%	8.0	10.0	8.0
Crude cellulose	%	4.0	4.0	4.0
Phosphorus	%	0.8	0.8	0.8
Vitamin A	U.I. kg^{-1}	10000	10000	10000
Vitamin D_3	U.I. kg^{-1}	1800	1800	1800
Vitamin E	mg kg^{-1}	60	60	60
Antioxidant BTH E_{321}	mg kg^{-1}	100	100	100
Crude energy	Mj kg^{-1}	19.4	18.4	18.1
Metabolic energy	Mj kg^{-1}	15.3	14.8	14.5
Granulation	mm	0.2	2.0	2.0

The food was applied daily, at 25% feeding level in the first week to 0.75% in the last week. Feeding rates per pond were adjusted weekly after weighting minimum 100 fish.

Water quality assessment. From each pond, water samples were collected daily, for analysis: temperature, dissolved oxygen and pH measurements. The instruments used were a thermometer/pH-meter HI 98128 and an oxygenmeter HI 9147, from Hanna Instruments Co.

Fish harvesting. At the end of the experiment ponds were drained and all fish were harvested and weighted. The technological indicators were calculated using the formulas:

Fish biomass gain (FBG): FBG = (Bf) - (Bi) [kg ha^{-1}]
with Bf – final fish biomass; Bi – initial fish biomass

Growth rate (GR): GR = (Bf- Bi)/t [kg fish biomass day^{-1}]
with Bf – final fish biomass; Bi – initial fish biomass, t - duration of the experiment

Specific growth rate (SGR): SGR = 100 * (ln Bf - ln Bi)/t [% fish biomass day^{-1}]
with Bf – final fish biomass, Bi – initial fish biomass, t - duration of the experiment

Feed conversion ratio (FCR): FCR = F/FBG [kg feed intake per kg fish biomass gain]
with F – feed intake, FBG – fish biomass gain

Protein efficiency ratio (PER): PER = FBG/(F * CP/100) [kg kg^{-1}]
with FBG – fish biomass gain, F – feed intake, CP - crude protein.

Statistical analysis. The mean values for final individual weight and water quality parameters from different treatments were compared using "student t test" for independent samples respectively one-way analysis of variance (ANOVA), after testing homogeneity of variance with Levene's test. Significant differences between group means were identified using the Duncan's multiple comparison test. Mean differences were considered significant at $p < 0.05$. Standard deviation in each parameter and treatment was calculated and expressed as „mean±SD". All statistical analyses were performed with the aid of a computerized statistical package, „SPSS for Windows" version 21.0.

Results and Discussion

Water quality assessment. Edwards (2015), showed that the modern aquaculture has a major adverse environmental impact, causing eutrophication because of intensification through increasing use of pelleted feed as well as expansion of the aquaculture area. Most feed nutrients consumed by fish are released into the immediate environment in which they are farmed as only about 1/3 of the nutrients in the feed are removed in the harvest of the fish with 2/3 voided by fish during growth. The potential adverse environmental impacts of aquaculture effluents increase from rice/fish culture, through ponds, and to raceway and cage culture, essentially in direct proportion to the degree of intensification through use of pelleted feed and the exchange of water between the internal environment of the culture system and the external environment.

The temperature during the experiment varied from 12.1 to 25.8°C. Except late September, the temperatures were maintained at an optimum for the growth of carp (Figure 1). In the four experimental ponds, water temperature registered similar dynamics with no statistical differences ($p > 0.05$) among mean values (20.72±3.82°C in V1R1; 20.66±3.68°C in V1R2; 20.70±4.04°C in V2R1; 20.62±4.00°C in V2R2). Song-bo et al (2012), investigated the feeding rhythm of common carp from 4°C to 34°C. The results indicated that there was a daily feeding rhythm for both adult (630-850 g $fish^{-1}$) and youngsters (61-91 g $fish^{-1}$) at all tested temperatures.

In both experimental variants and replicates the dissolved oxygen registered values from 5.9 mg L^{-1} (in August) to 8.6 mg L^{-1} (in September), thus variating within optimal range for carp rearing (Figure 2). The statistical comparisons of mean values of dissolved oxygen measured in all four ponds (6.92±0.57 mg L^{-1} in V1R1, 6.84±0.61 mg L^{-1} in V1R2, 6.93±0.75 mg L^{-1} in V2R1, 6.92±0.76 mg L^{-1} in V2R2) showed no significant differences ($p > 0.05$) among treatments.

Throughout the period of the experiment, the pH values varied between 7.19-8.52 units values within optimal range for the growth of carp juveniles (Figure 3). The statistical comparisons of mean values of pH measured in all four ponds (7.97±0.54 in V1R1, 7.94±0.51 in V1R2, 7.93±0.50 in V2R1, 7.91±0.48 in V2R2) showed no significant differences ($p > 0.05$) among treatments.

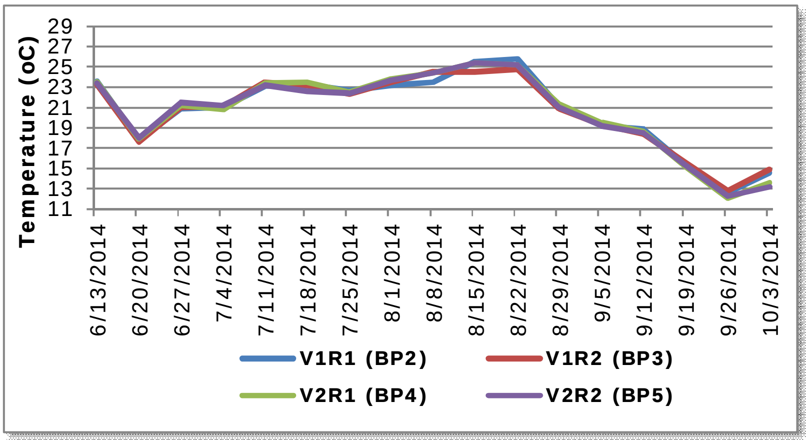

Figure 1. Water temperature dynamics.

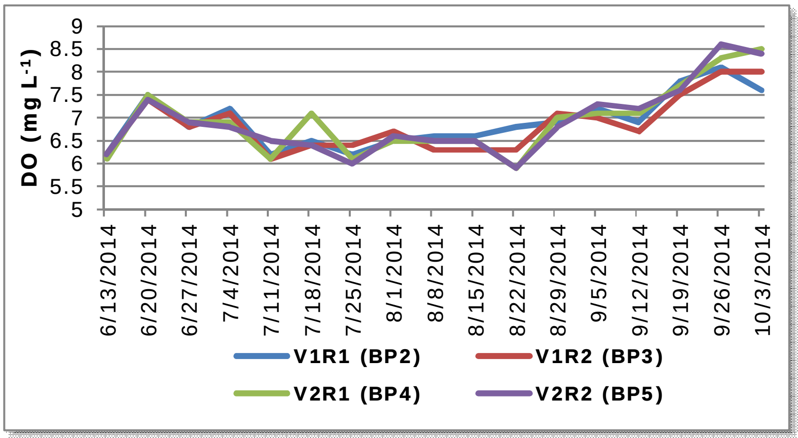

Figure 2. Dissolved oxigen dynamics.

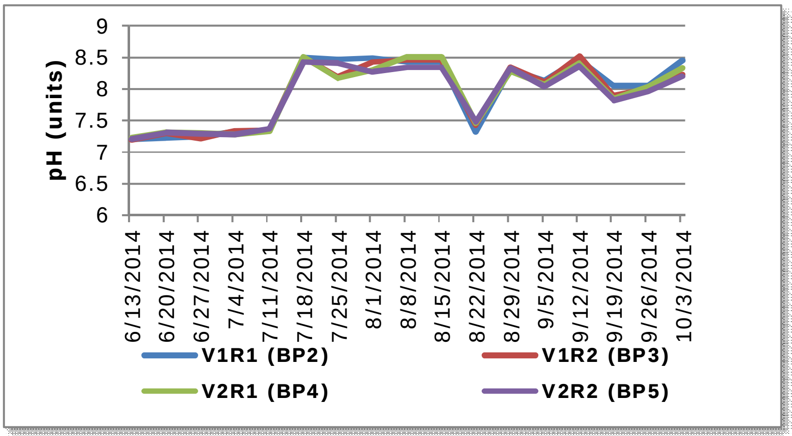

Figure 3. Water pH dynamics.

Growth performance of fish. The influence of food quality on growth performance of one summer common carp can be analyzed using some parameters (Table 2).

Table 2

Growth performance of one summer common carp

Indicators	*Experimental variant*					
	V1			*V2*		
	V1R1 (BP2)	*V1R2 (BP3)*	*MEAN*	*V2R1 (BP4)*	*V2R2 (BP5)*	*MEAN*
Initial fish biomass (kg ha^{-1})	30.00	30.00	30.00	30.00	30.00	30.00
Final fish biomass (kg ha^{-1})	3900.00	3810.00	3855.00	3600.00	3480.00	3540.00
Fish biomass gain (kg ha^{-1})	3870.00	3780.00	3825.00	3570.00	3450.00	3510.00
Initial number of fish (fish ha^{-1})	30000	30000	30000	30000	30000	30000
Final number of fish (fish ha^{-1})	25160	14940	20050	20570	21614	21092
Survival (%)	84.00	50.00	67.00	69.00	72.00	70.00
Initial mean body weight (kg $fish^{-1}$)	0.001	0.001	0.001	0.001	0.001	0.001
Final mean body weight (kg $fish^{-1}$)	0.155	0.255	0.205	0.175	0.161	0.168
Individual weight gain (kg $fish^{-1}$)	0.154	0.254	0.204	0.174	0.160	0.167
Experiment duration (days)	120	120	120	120	120	120
Growth rate (GR) (kg fish biomass day^{-1})	32.25	31.50	31.88	29.75	28.75	29.25
Specific growth rate (SGR) (% fish biomass day^{-1})	4.06	4.04	4.05	3.99	3.96	3.98
Food quantity intake (kg)	4826.00	4826.00	4826.00	4826.00	4826.00	4826.00
Feed conversion ratio (FCR) (kg kg^{-1})	1.25	1.28	1.26	1.35	1.40	1.38
Protein efficiency ratio (PER) (kg kg^{-1})	2.41	2.36	2.39	2.60	2.51	2.55
Fodder crude energy (Mj kg^{-1})	19.40/ 18.40	19.40/ 18.40	19.40/ 18.40	19.40/ 18.10	19.40/ 18.10	19.40/ 18.10
Fodder metabolic energy (Mj kg^{-1})	15.30/ 14.80	15.30/ 14.80	15.30/ 14.80	15.30/ 14.50	15.30/ 14.50	15.30/ 14.50
Crude protein of pellets (%)	48.00/ 35.00	48.00/ 35.00	48.00/ 35.00	48.00/ 30.00	48.00/ 30.00	48.00/ 30.00

Boyd (2015) showed that manufactured feeds are designed according to the nutritional requirements of fish species. These feeds are composed from a wide range of high quality feedstuffs to include fish meal, squid meal, plant meals, crushed corn, wheat flour, rice flour, meat scrap meals, feather meal, bone meal, distillers dried soluble, fish oil, vegetable oil, vitamins, mineral supplements, antioxidants etc. Typically, feeds are formed by controlling the size of pellets to accommodate various species and growth stages for which they are intended.

The main type of culture systems in Eastern Europe as well as in Romania is the semi-intensive system, which is characterized by addition of cereals to natural food, in order to meet energy requirement of fish. The extruded/expanded diets are quite new in carp production and these diets have significantly increased the production of common carp on fish farms from 1000 to over 3000 kg ha^{-1} (Ljubojevic et al 2015).

During the trial, increases in both individual body weight and fish biomass for the two experimental feed quality were detected. After 120 days, at the end of the experiment, a direct pattern of changes in individual body weight was observed with respect to feed crude protein and crude energy of feed (Figure 4).

There were higher values of fish individual gain in V1 variant (0.204 kg $fish^{-1}$), where feed quality, in terms of protein content, was higher (48-35% crude protein) compared with V2 variant, pellets with 48-30% crude protein, where and consequently individual gain was lower (0.167 kg $fish^{-1}$). Fish survival rate in both treatments registered 67% and 70% in V1 and V2 variants, respectively (Figure 4).

Statistic comparison of the mean final fish weight revealed significant differences (ANOVA, $p < 0.05$) among all groups (both trials and replicates), post hoc test (Duncan test) emphasizing as a distinct group V1R2 replicate where the mean final weight (0.25±0.005 kg $individual^{-1}$) was significantly different comparing with other 3 ponds. Thus, in V1R1 variant the mean individual final weight was 0.151±0.004 kg $individual^{-1}$, in V1R2 0.25±0.005 kg $individual^{-1}$, in V2R1 0.17±0.004 kg $individual^{-1}$ and in V2R2 0.16±0.004 kg $individual^{-1}$. The better growth registered in V1R2 variant is explained by lowest density which appeared as a result of high mortality (50%) in this pond. In fact, for all groups was detected a negative correlation (R^2 = 0.89) between survival rate and individual weight gain (Figure 5). The mean biomass gain was 3825 kg ha^{-1} in V1, compared with 3510 kg ha^{-1} in V2. This was correlated with both environmental conditions (more space and higher natural food availability for batches with lower survival rate) and quality of pellets used, more favorable in V1. The mean growth rate of fish biomass (GR) varied in a similar way, from 3188 kg day^{-1} in V1 to 29.25 kg day^{-1} in V2. The differences was also influenced by the pellets quality (Figure 6).

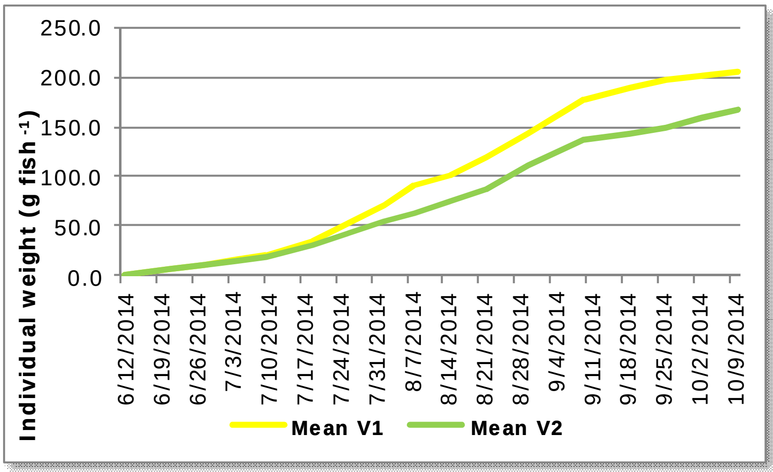

Figure 4. Individual mean body weight gain and survival of fish.

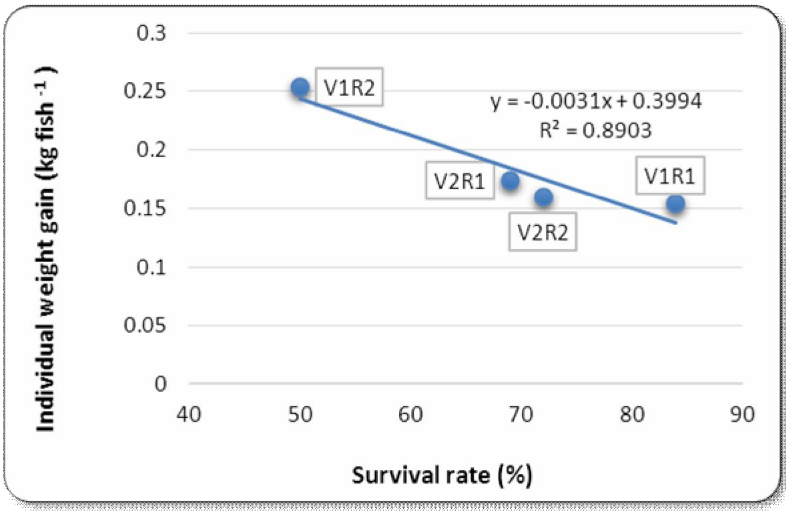

Figure 5. Individual mean body weight gain versus fish survival.

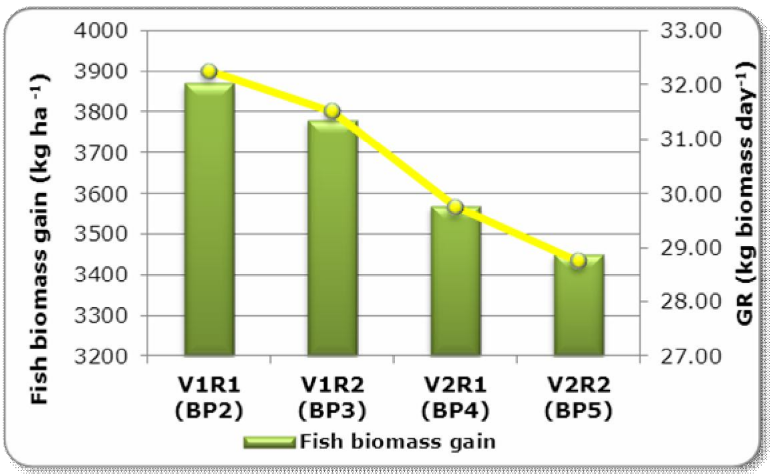

Figure 6. Fish biomass gain and growth rate.

The mean specific growth rate of fish biomass (SGR) was 4.05% day^{-1} in V1 and 3.98% day^{-1} in V2. This shows that the fish growth was very good, in both variants. The mean feed conversion ratio (FCR) was 1.26 kg of pellets per kg weight gain in V1 and 1.38 kg of pellets per kg weight gain in V2. The quality of fodder positively influenced the FCR final value (Figure 7). The values of FCR obtained in the current study are lower then those reported for common carp in earlier studies (Firas & Ramadan 2012).

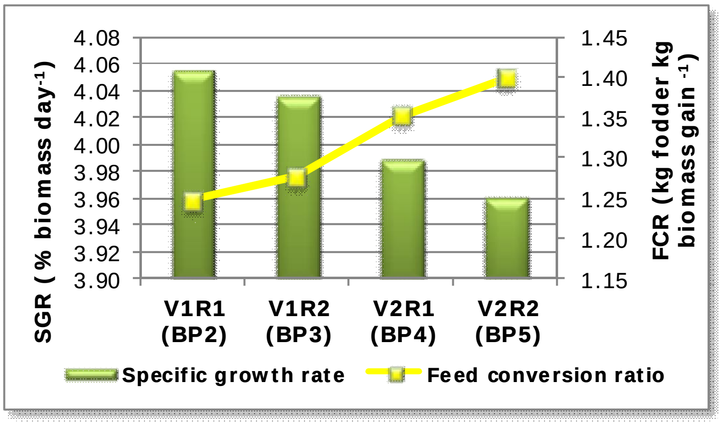

Figure 7. Specific growth rate and feed conversion ratio.

Different authors indicated for fish that dietary protein level is an essential factor in increasing the growth performance and production of reared fish. It is well known that fish preferentially utilize dietary protein as an energy source rather than lipid or carbohydrate, so it is important to optimize protein utilization for tissue synthesis rather than for energy purposes (Jin et al 2015; Oprea & Oprea 2009; Yilmaz et al 2005; Belal 2005).

Overall, protein efficiency ratio (PER) had similar values of 2.39 and 2.55 in the V1 respectively V2 treatment. Slightly better value registered in V2 is justified by the lower amount of protein administered here, although, in all cases, was distributed the same amount of food. It follows that 30% crude protein is also recommended for rearing juvenile carp. However, using feed with 35% protein offers the advantage of obtaining a larger final production. Other authors (Stankovic et al 2010) found that common carp can make good use of dry feeds, yielding entirely acceptable growth performance and feed efficiency.

Conclusions. Strong synergistic effects in terms of availability of food, food intake, growth and production were obtained in ponds with 30,000 common carp fry ha^{-1}. As expected, the good quality of supplementary feeds utilization influenced the growth performance of fish.

The fish breeding parameters showed that variation in food quality, in term of crude protein and gross energy, positively influenced fish biomass gain and feed conversion. The use of high protein feeds in semi-intensive aquaculture proved to have positive effects on fish growth and led to an increase in common carp yield per unit of volume.

The results of our research are more applicable to the aquaculture industry, because it was conducted in real production conditions. This however raises a question of sustainability, i.e. its economic, social and especially environmental (water quality) impact, needing further investigation.

Acknowledgements. The work has been funded by the Sectoral Operational Programme Human Resources Development 2007-2013 of the Ministry of European Funds through the Financial Agreement POSDRU/159/1.5/S/132397.

References

Belal I. E. H., 2005 A review of some fish nutrition methodologies. Bioresource Technology 96:395-402.

Boyd C. E., 2015 Overview of aquaculture feeds: global impacts of ingredient use. Feed and Feeding Practices in Aquaculture, Vol. Woodhead Publishing Series, Food Science, Technlogy and Nutrition, pp. 3-25.

Ciric M., Subakov-Simic G., Dulic Z., Bjelanovic K., Cicovacki S., Markovic Z., 2015 Effect of supplemental feed type on water quality, plankton and benthos availability and carp (*Cyprinus carpio L.*) growth in semi-intensive monoculture ponds. Aquaculture Research 46(4):777-788.

Edwards P., 2015 Aquaculture environment interactions: past, present and likely future trends. Aquaculture 447:2-14.

FAO, 1995 Fisheries circular nr.886/Review of the state of world fishery resources, aquaculture.

FAO, 2012 Aquaculture production 2010. FAO Yearbook of Fisheries Statistics.

FAO, 2015 Fisheries and Aquaculture Statistics/Global Aquaculture Production 1950-2013.

Firas A., Ramadan S., 2012 Evaluation of common carp *Cyprinus carpio* L. performance fed at three commercial diets. Mesopotamia Journal of Agriculture 40(4):20-26.

Green B. W., 2015 Fertilizers in aquaculture. Feed and Feeding Practices in Aquaculture, Vol. Woodhead Publishing Series, Food Science, Technlogy and Nutrition, pp. 27-52.

Hepher B., 1988 Nutrition of pond fishes. Cambridge University Press, 388 pp.

Horvath L., Tamas G., Seagrave C., 1992 Carp and pond fish culture: including Chinese herbivorous species, pike, tench, zander, wels catfish and goldfish. Fishing News Books, Oxford, 158 pp.

Jin Y., Tian L., Xie S., Guo D., Yang H., Liang G., Liu Y., 2015 Interactions between dietary protein levels, growth performance, feed utilization, gene expression and metabolic products in juvenile grass carp (*Ctenopharyngodon idella*). Aquaculture 437:75-83.

Ljubojevic D., Radosavljevic V., Puvac N., Zivkov Balos M., Đorpevic V., Jovanovic R., Cirkovic M., 2015 Interactive effects of dietary protein level and oil source on proximate composition and fatty acid composition in common carp (*Cyprinus carpio* L.). Journal of Food Composition and Analysis 37:44-50.

Lovell T., 1989 Nutrition and feeding of fish. Van Nostrand Reinhold, New York, USA.

Oprea L., Georgescu R., 2000 [Fish nutrition and feeding]. Bucharest, Technical Publishing House, ISBN 973-31-1483-9, 272 pp. [in Romanian]

Oprea D., Oprea L., 2009 Researches considering the effect of gradually insertion of fodder in alimentation for the growth rhytm of Siberian sturgeon larvae (*Acipenser baerii,* Brandt, 1869) reared in superintensive system. Univ. „Dunarea de Jos", Proceedings of the International Symposium Euroaliment, Galati.

Song-bo C., Wei-xing C., Zhao-ting F., 2012 Effect of water temperature on feeding rhythm in common carp (*Cyprinus carpio haematopterus,* Temminck et Schlegel). Journal of Northeast Agricultural University (English Edition) 19(1):57-61.

Stankovic M., Markovic Z., Dulic Z., Raskovic B., Zivicand I., Lakic N., 2010 Effect of feeding frequencies on carp growth rate - preliminary results. Bulgarian Journal of Agricultural Science 16:317-321.

Yilmaz E., Sahin A., Duru M., Akyurt I., 2005 The effect of varying dietary energy on growth and feeding behaviour of common carp, *Cyprinus carpio*, under experimental conditions. Applied Animal Behaviour Science 92:85-92.

Received: 20 July 2015. Accepted: 17 August 2015. Published online: 28 August 2015.
Authors:
Mihai C. Mocanu, "Dunărea de Jos" University of Galaţi, Faculty of Food Science and Engineering, Department of Aquaculture, Environmental Sciences and Cadastre, Domnească Str. 47, 800008 Galaţi, Romania, e-mail: mcornelmocanu@yahoo.com
Tiberiu Vanghelie, "Dunărea de Jos" University of Galaţi, Faculty of Food Science and Engineering, Department of Aquaculture, Environmental Sciences and Cadastre, Domnească Str. 47, 800008 Galaţi, Romania, e-mail: tibi_63@yahoo.com
Petronela G. Sandu, "Dunărea de Jos" University of Galaţi, Faculty of Food Science and Engineering, Department of Aquaculture, Environmental Sciences and Cadastre, Domnească Str. 47, 800008 Galaţi, Romania, e-mail: petronela.sandu@ugal.ro
Lorena Dediu, "Dunărea de Jos" University of Galaţi, Faculty of Food Science and Engineering, Department of Aquaculture, Environmental Sciences and Cadastre, Domnească Str. 47, 800008 Galaţi, Romania, e-mail: lorena.dediu@ugal.ro
Lucian Oprea, "Dunărea de Jos" University of Galaţi, Faculty of Food Science and Engineering, Department of Aquaculture, Environmental Sciences and Cadastre, Domnească Str. 47, 800008 Galaţi, Romania, e-mail: lucian.oprea@ugal.ro

How to cite this article:
Mocanu M. C., Vanghelie T., Sandu P. G., Dediu L., Oprea L., 2015 The effect of supplementary feeds quality on growth performance and production of common carp (*Cyprinus carpio* L.) at one summer of age, in ponds aquaculture systems. AACL Bioflux 8(4):602-610.