KRMIVA

ISSN 0023-4850 (Tisak)
ISSN 1848-901X (Online)

THE INFLUENCE OF PROBIOTIC-ENRICHED FEED ON FULTON'S COEFFICIENT AND BODY MASS OF THE COMMON CARP (*CYPRINUS CARPIO*) REARED IN AN INTENSIVE CAGE SYSTEM

UTJECAJ HRANE OBOGAĆENE PROBIOTIKOM NA FULTONOV KOEFICIJENT I TJELESNU MASU ŠARANA (*CYPRINUS CARPIO*) UZGAJANOGA U INTENZIVNOME KAVEZNOM SUSTAVU

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Original scientific paper - Izvorni znanstveni članak
Received - Primljeno: 31. March – ožujak 2025
Revised - Revidirano: 22. May - svibanj 2025
Accepted - Prihvaćeno: 23. May – svibanj 2025
https://doi.org/10.33128/k.67.1.4
UDK 639.31.043:597.551.2

SUMMARY

In this research, the common carp (*Cyprinus carpio*) was observed in two experimental groups with a probiotic-enriched feed. Group A received a lower concentration of probiotics and Group B a higher concentration of probiotics in the feed. The fish in the Control Group (C) did not receive any probiotics in their feed. Fulton's condition factor and body mass were monitored by five control measurements. During the five control periods, the average body mass of the common carp in the Experimental Groups A and B displayed the significantly higher values when compared with the Control Group. Fulton's condition factor was significantly lower in the Control Group (C) than in the two experimental groups, while no statistically significant difference was detected between the Groups A and B. These results indicate that a probiotic supplementation in aquacultural feed has a positive effect on the fish growth and its overall condition.

Keywords: probiotic enriched feed, *Cyprinus carpio*, body mass, condition factor

INTRODUCTION

As an alternative to antibiotics and chemical agents, the use of probiotics in aquaculture provides significant benefits, such as an improved fish health, growth, survival rates, and, most importantly, technological advantages in fish production, including an enhanced production performance and economic profitability (Gupta et al. 2014). A modern generation of probiotics is being developed to meet the demands of sustainable aquaculture (i.e., an intensive carp rearing) through the two key factors: growth performance and disease resistance (Dawood et al., 2015).

Since the management of fish-farming systems varies significantly at every level, an approach to administration, concentration, and the selection of appropriate probiotics is crucial for the achievement of successful results in a technological process (Jahangiri et al., 2018). A proper selection of probiotics is a critical aspect of managing the technological process, as some species or strains of bacteria may exert undesirable effects on fish (Yun-Zhang Sun et al., 2010). An appropriate selection of probiotics depends on a type of fish reared, technology and

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farming conditions (i.e., cage systems, ponds, or open waters), as well as a desired effect exerted on the fish: an immune stimulation, disease prevention, or the improvement of production traits (Merrifield et al., 2010, Manevska et al. 2024). There has been a growing number of recent studies focusing on a method of probiotic administration in aquaculture (added to the feed or the water). A treatment duration, dosage (concentration), and a probiotic source are the most important factors determining their activity and impact on the fish reared in aquaculture (Cabello, 2006; Dawood et al., 2015; Hai, 2015).

As noted by the aforementioned authors, its application method, concentration, fish species or farming system, and the use of probiotics ensures a positive production performance (i.e., the growth and feed conversion) regardless of a probiotic type. These conclusions are based upon the results obtained from the studies conducted on the fish reared under laboratory/controlled conditions, whereas the data on the application of probiotics in a diet of a carp reared in the intensive cage systems are almost non-existent (Manevska et al. 2024a).

An impact of probiotics on the Fulton's condition factor K of the carp (*Cyprinus carpio*) is a significant topic in aquaculture and fish biology. Fulton's condition factor (K) is a measure applied to assess the health and physical condition of fish. When administered in the appropriate amounts, the probiotics are the live microorganisms that can improve the health and growth of the fish (Manevska et al. 2024b). One of the positive effects of probiotics on the carp includes the optimization of their condition: the fish fed with a probiotic-enriched feed often exhibit a better Fulton's condition factor, indicating a generally improved fitness and a better energy storage (Mihai et al. 2023, Manevska et al. 2024c).

In this context, the research conducted in this experiment represents the first step toward gaining the new insights into the effects of the applied probiotic in an intensive aquacultural carp farming in Macedonia. The aim of this study was to apply the probiotic *Paenibacillus alvei* in a technological farming process (i.e., a practical application) to achieve the positive results, inspired by a knowledge of the positive effects of probiotics on the condition factor and body mass of the fish reared under the controlled experimental conditions.

MATERIALS AND METHODS

Study Location and Experimental Conditions

The research was conducted at a cage-based aquacultural facility situated in the Kozjak Reservoir. The setup included three individual cages, each with the dimensions of 5 × 5 × 5 m (totaling a volume of 125 m^3). These were labeled as the Groups A, B, and C. The experimental period spanned over 2.5 months, during which four sampling sessions were carried out at regular intervals ranging from 11 to 16 days. In each session, 30 fish were randomly sampled from every group. An initial sampling served as a baseline and was completed prior to the inclusion of a probiotic in the feed.

Biological Material

A total of 1,000 carp fish were selected for the study. An equal number of individuals (323 per group) were stocked in each cage. A mean starting weight of the fish amounted to approximately 170 g. After stocking, each group's collective biomass was determined and recorded as an initial group weight.

Feed and Chemical Analysis

The fish were fed a commercial pelleted diet manufactured by the Austrian company Aqua, with the pellet diameters ranging from 4 to 6 mm. A declared nutritional composition of the feed was as follows:

- protein: 30%
- fat: 10%
- crude fiber: 4.5%
- ash: 6.5%
- calcium (Ca): 0.90%
- sodium (Na): 0.25%
- phosphorus (P): 1.10%

The feed was analyzed in the Laboratory of the UKIM Institute of Animal Science and Fishery while applying the standard chemical methods:

- moisture content: determined by drying at 105°C until a constant weight
- crude protein: Kjeldahl method (N × 6.25)
- crude fat: Soxhlet extraction with the diethyl ether
- crude fiber: standard fiber determination methods
- ash: combustion at 600°C for 8 hours

Probiotic Preparation and Application

The probiotic strain *Paenibacillus alvei* DZ-3 was prepared in the Microbiological Laboratory at the Faculty of Natural Sciences and Mathematics in Skopje. The preparation steps included the following:

1. a 24-hour bacterial culture was incubated at 37°C;
2. the culture was propagated in a nutrient broth at 37°C for 24 h, with shaking at 180 rpm;
3. the biomass was harvested by centrifugation at 4,000 rpm for 15 min.;
4. the cells were washed twice with 5 ml of the phosphate-buffered saline (PBS, pH 7.2); and
5. the final suspension was adjusted to 1.5 $\times$ 10^8 CFU/ml (equivalent to 0.5 McFarland standard).

Probiotic dosing:

- Group A: 1 ml of probiotic per kg of feed
- Group B: 2 ml of probiotic per kg of feed
- Group C: Control group, received standard feed with no probiotic

A liquid probiotic was sprayed onto the feed pellets and mixed for 3 min, followed by additional 5 min of mixing. The prepared feed was spread in a 2 cm layer in a dry, ventilated area and left to dry for 2 h. A fresh probiotic-treated feed was prepared every two weeks.

Feeding Protocol

The fish were fed continuously applying the automatic feeders operating 24 h a day. Daily feeding rates were determined based upon the manufacturer's feeding table, which considers the water temperature and the fish body weight.

Meristic Measures

During each sampling, the following parameters were recorded:

a) W—individual body mass;
b) L—total body length (from the mouth to the end of the tail);
c) Ls—standard body length (from the mouth to the notch of the caudal fin);
d) fl—body length from the mouth to the base of the tail;
e) h—body height (from the ventral to the dorsal fin);
f) total fish biomass per group;
g) individuals (number) / group;
h) average and initial body weight of the 30 sampled individuals.

The fish condition was evaluated applying Fulton's Condition Factor (K), calculated applying the following formula:

$$K = (Wg / Lcm) \times 100$$

Statistical Methods

All collected data were statistically analyzed applying the following instruments:

- analysis of variance
- Tukey's post hoc test for group comparisons
- descriptive statistics, including the minimum and maximum values, and standard deviation (SD)
- coefficient of variation (CV)

RESULTS AND DISCUSSION

Fish Body Mass

A difference in the fish's body mass was observed based upon the successive experimental control measurements figured in Table 1.

Table 1 A total fish's body mass (g) of 30 carp individuals from the experimental groups (A, B, and C) during the first to the fourth control measurement

Tablica 1. Ukupna tjelesna masa riba (g), odnosno 30 jedinaka šarana iz eksperimentalnih skupina (A, B i C), tijekom I. – IV. kontrolnog mjerenja

Group* Skupina	Start Početak	1st measurement I. mjerenje	2nd measurement II. mjerenje	3rd measurement III. mjerenje	4th measurement IV. mjerenje
A	5184	6680	8688	12257	15696
B	5172	6520	7996	11169	14224
C	5163	6581	7633	10060	12328

*Group A – the fish fed with a commercial feed supplemented with the *Paenibacillus alvei* at 1 ml/kg; Group B – the fish fed with a commercial feed supplemented with the *Paenibacillus alvei* at 2 ml/kg; and Group C – Control group, the fish fed with a commercial feed only (no probiotic added).
*Skupina A – ribe hranjene komercijalnom hranom s dodatkom *Paenibacillus alvei* u količini od 1 ml/kg; Skupina B – ribe hranjene komercijalnom hranom s dodatkom *Paenibacillus alvei* u količini od 2 ml/kg; Skupina C – ribe kontrolne skupine, hranjene samo komercijalnom hranom (bez dodanog probiotika)

A difference in the fish's body mass was observed based upon the successive control measurements of the experiment figured in Table 1. An increase in the body-mass values was evident in the fish from the Experimental Group A already in the second control measurement, having reached the value of 8688 g and having been followed by 7996 g for the fish from the Experimental Group B, while the Control Group C had a slightly lower body mass, having amounted to 7633 g. A similar increasing trend in the fish's body mass was observed during the third measurement in the Experimental Groups A and B, having reached 12,257 g and 11,169 g, respectively, in contrast to the Control Group C, in which the fish's body mass amounted to 10,060 g (Fig. 1). The fourth control measurement presented a greater difference in the carp's body-mass values between the experimental groups, with the Group A reaching 15,696 g and the Group B reaching 14,224 g, if compared with the Control Group C, whose carp individuals had a body mass of 12,328 g.

To determine a statistically significant mean mass of the fish from the three groups during the four control measurements and the fifth measurement (final assessment), a univariate analysis of variance (ANOVA) was performed. A determination of significant differences ($p < 0.05$) between the examined groups was conducted while administering the post hoc Tukey's test (Table 2).

The analysis of variance proved that the fish's body mass in the experimental groups during the first and the second control measurements did not differ from a statistical significance. In the third and the fourth measurements, a higher fish mass in the Group A significantly differed ($p < 0.05$) from a lower mass of the Group C. During the third and the fourth measurement, the fish's body weight in the Group B did not manifest a statistically significant difference when compared with either the Group A or the Control Group C.

Regarding the fifth measurement, a univariate ANOVA indicated that a lower weight mass of the Control Group significantly differed from the higher

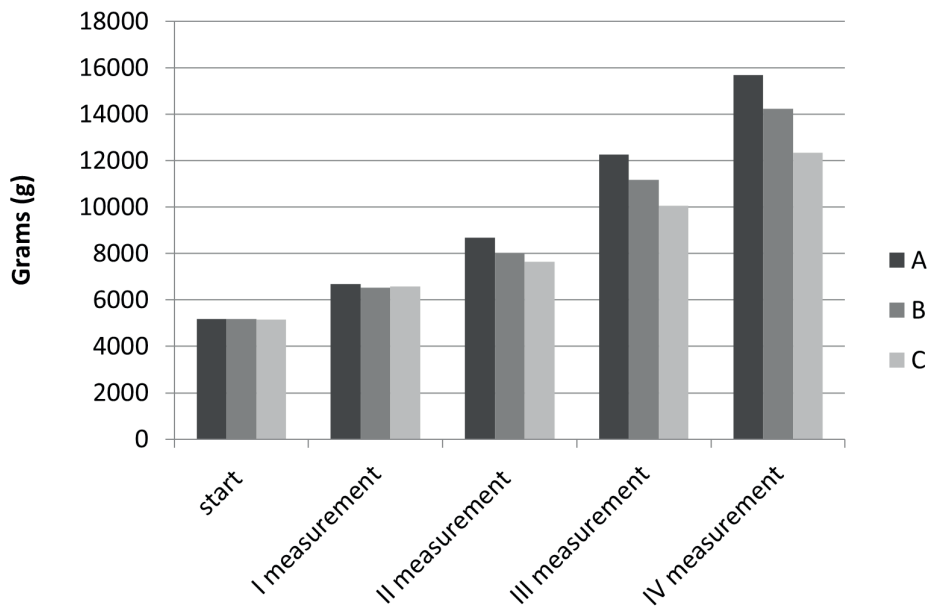

Figure 1 A mass (g) of 30 units from the Experimental Groups (A, B, and C) at the start of the experiment and during the first to the fourth control measurement.
Slika 1. Masa (g) 30 jedinaka iz eksperimentalnih skupina (A, B i C) na početku eksperimenta i tijekom I. – IV. kontrolnog mjerenja.

*Group A – the fish fed with a commercial feed supplemented with the *Paenibacillus alvei* at 1 ml/kg; Group B – the fish fed with a commercial feed supplemented with the *Paenibacillus alvei* at 2 ml/kg; and Group C – control group, the fish fed with a commercial feed only (no probiotic added).
*Skupina A – ribe hranjene komercijalnom hranom s dodatkom *Paenibacillus alvei* u količini od 1 ml/kg; Skupina B – ribe hranjene komercijalnom hranom s dodatkom *Paenibacillus alvei* u količini od 2 ml/kg; Skupina C – ribe kontrolne skupine, hranjene samo komercijalnom hranom (bez dodanog probiotika)

mass values observed in the Experimental Groups A and B. However, no statistically significant difference was detected between the two experimental groups in terms of a body mass (Fig. 1).

In the course of five measurements, the average body mass of the common carp individuals from the Experimental Group A presented significantly higher values ($p < 0.05$) if compared with the average mass of the common carp individuals from the Control Group (408.57 g in the Group A and 335.33 g in the Group C, having been a difference of 73.24 g, or of 17.93%).

During five monitoring sessions, the average mass of the common carp individuals from the Experimental Group B presented significantly higher values ($p < 0.05$) if compared with the average mass of the common carp individuals from the Control Group (372.3 g in the Group B and 335.33 g in the Group C, having been a difference of 36.97 g, or of 9.94%).

Condition Factor—Fulton's Coefficient (K)

Based upon the obtained parameters of morphological-meristic measurements, a descriptive analysis of the calculated condition factor (K) was conducted. Below is the Table 3 representation of a descriptive analysis of Fulton's coefficient values for all three groups, A, B, and C.

In Table 3, a descriptive analysis presents a minimum, maximum, mean value, variance, and standard deviation for all five control measurements of the Groups A, B, and C. Notably, during the fourth control measurement, there was a difference in the values of Fulton's coefficient among all three groups. In the final fifth measurement, the Experimental Groups A and B had the mean values of 1.89 and 1.86, respectively, if compared with the Control Group C, whose mean Fulton's coefficient value amounted to 1.49.

To determine a statistically significant difference ($p < 0.05$), an analysis of variance (ANOVA) was conducted. A tabular representation of a variance analysis of Fulton's coefficient values for the common carp individuals from all three experimental groups within the first phase is constructed.

From the first to the third control measurement, the analysis of variance (ANOVA) of Fulton's coefficient values indicated no statistically significant difference between the Experimental Groups A, B, and C. During the fourth control measurement, the values of Fulton's coefficient exhibited a statistically significant difference ($p < 0.05$) among all three experimental groups. A variance analysis of the final fifth measurement indicated that a low value of Fulton's coefficient in the Control Group C statistically significantly differed if compared with the

Table 2 The analysis of variance (ANOVA) of the mean body mass (g) of 30 individuals from the Experimental Groups (A, B, and C) during the first to the fourth control measurement

Tablica 2. Analiza varijance (ANOVA) prosječne tjelesne mase (g) 30 jedinaka iz eksperimentalnih skupina (A, B i C) tijekom I. – IV. kontrolnog mjerenja

Group Skupina	1st measurement I. mjerenje	2nd measurement II. mjerenje	3rd measurement III. mjerenje	4th measurement IV. mjerenje	5th measurement V. mjerenje
	$\bar{x}$(SD)	$\bar{x}$(SD)	$\bar{x}$(SD)	$\bar{x}$(SD)	$\bar{x}$(SD)
A	174.20 (37.05)^{a}	222.67 (44.13)^{a}	289.60 (64.35)^{a}	408.57 (85.06)^{a}	483.47 (99.36)^{a}
B	179.13 (31.29)^{a}	197.70 (41.58)^{a}	266.53 (38.92)^{ab}	372.30 (67.33)^{ab}	500.00 (87.94)^{a}
C	194.57 (36.82)^{a}	219.37 (38.60)^{a}	254.43 (47.36)^{b}	335.33 (58.05)^{b}	370.77 (59.01)^{b}

*The different letters in a superscript in a single column indicate the statistically significant values ($p < 0.05$).
*Različita slova u indeksu unutar iste kolone označuju statistički značajne vrijednosti ($p < 0,05$).

*Group A—a variance analysis of the fish fed with a commercial feed supplemented with the *Paenibacillus alvei* at 1 ml/kg; B—a variance analysis of the fish fed with a commercial feed supplemented with the *Paenibacillus alvei* at 2 ml/kg; and C—a variance analysis of the Control Group, the fish fed with a commercial feed only (no probiotic added).
*Measurement: represents the sequential sampling points during a 2.5-month experiment.
*Skupina A - analiza varijance riba hranjenih komercijalnom hranom s dodatkom *Paenibacillus alvei* u količini od 1 ml/kg; B - analiza varijance riba hranjenih komercijalnom hranom s dodatkom *Paenibacillus alvei* u količini od 2 ml/kg; i C - analiza varijance kontrolne skupine, riba hranjenih samo komercijalnom hranom (bez dodanog probiotika).
*Mjerenje: predstavlja uzastopne točke uzorkovanja tijekom 2,5-mjesečnog eksperimenta.

Table 3 A descriptive analysis of a central tendency and the dispersion-measurement values of Fulton's coefficient for all three groups (A, B, and C) during the first to the fourth control measurement

Tablica 3. Deskriptivna analiza vrijednosti središnje tendencije i mjerenja disperzije Fultonova koeficijenta za sve tri skupine (A, B i C) tijekom I. – IV. kontrolnog mjerenja

Group* Skupina	Measurement* Mjerenje	Min*	Max*	$\bar{x}$*	Variance* Varijanca (n-1)	(SD)* (n-1)	CV*
A	I	1.18	1.65	1.37	0.01	0.10	0.07
	II	1.29	1.86	1.59	0.02	0.15	0.09
	III	1.57	2.27	1.82	0.03	0.17	0.09
	IV	1.72	2.35	1.98	0.03	0.17	0.08
	V	1.63	2.22	1.89	0.03	0.16	0.09
B	I	1.16	1.70	1.42	0.02	0.13	0.09
	II	1.26	2.49	1.58	0.08	0.27	0.17
	III	1.50	2.02	1.75	0.02	0.14	0.08
	IV	1.68	2.09	1.87	0.01	0.11	0.06
	V	1.39	2.20	1.86	0.03	0.18	0.10
C	I	1.12	1.58	1.41	0.01	0.10	0.07
	II	1.37	2.09	1.66	0.02	0.15	0.09
	III	1.44	2.10	1.78	0.03	0.16	0.09
	IV	1.51	1.93	1.72	0.01	0.10	0.06
	V	1.29	1.72	1.49	0.01	0.11	0.07

*Fulton's coefficient: Group A—the fish fed with a commercial feed supplemented with the *Paenibacillus alvei* at 1 ml/kg; Group B—the fish fed with a commercial feed supplemented with the *Paenibacillus alvei* at 2 ml/kg; and Group C—a control group, fed with a commercial feed only (no probiotic added); *Min—minimum value/*Max—maximum value; *$\bar{x}$—an arithmetic mean (average), a measured value for each group at each measurement; *Variance (n−1)—a sample variance using the n-1 freedom; *Measurement: represents the sequential sampling points during a 2.5-month experiment. Measurement I was taken prior to a probiotic application. [3]The mean ($\bar{x}$) shows the average; *SD (n−1)—a sample standard deviation (square root of variance), also using n−1; *CV—coefficient of variation

*Fultonov koeficijent: Skupina A - ribe hranjene komercijalnom hranom s dodatkom *Paenibacillus alvei* u količini od 1 ml/kg; Skupina B - ribe hranjene komercijalnom hranom s dodatkom *Paenibacillus alvei* u količini od 2 ml/kg; i Skupina C - kontrolna skupina, hranjena samo komercijalnom hranom (bez dodanog probiotika);

*Min - minimalna vrijednost / *Max - maksimalna vrijednost; *$\bar{x}$ - aritmetička sredina (prosjek), izmjerena vrijednost za svaku skupinu pri svakom mjerenju; *Varijanca (n-1) - varijanca uzorka korištenjem n-1 slobode; *Mjerenje: predstavlja uzastopne točke uzorkovanja tijekom 2,5-mjesečnog eksperimenta. Mjerenje uzeto prije primjene probiotika. 3Srednja vrijednost ($\bar{x}$) pokazuje prosjek; *SD (n-1) - standardna devijacija uzorka (kvadratni korijen varijance), također korištenjem n-1; *CV - koeficijent varijacije

Table 4 An analysis of variance (ANOVA) of Fulton's coefficient values for all three groups (A, B, and C) from the first to the fifth control measurement

Tablica 4. Analiza varijance (ANOVA) vrijednosti Fultonova koeficijenta za sve tri skupine (A, B i C) iz I. – V. kontrolnog mjerenja

Group Skupina	I	II	III	IV	V
A	1.36 (0.01)^{a}	1.58 (0.15)^{a}	1.82 (0.17)^{a}	1.97 (0.17)^{a}	1.89 (0.16)^{a}
B	1.42 (0.13)^{a}	1.58 (0.27)^{a}	1.75 (0.14)^{a}	1.87 (0.11)^{b}	1.85 (0.18)^{a}
C	1.41 (0.10)^{a}	1.65 (0.15)^{a}	1.77 (0.16)^{a}	1.71 (0.10)^{c}	1.48 (0.11)^{b}

*The different letters in a superscript in a single column indicate the statistically significant values ($p < 0.05$).

*Različita slova u indeksu unutar iste kolone označuju statistički značajne vrijednosti ($p < 0,05$).

*A—Fulton's coefficient, a variance analysis of the fish fed with a commercial feed supplemented with the *Paenibacillus alvei* at 1 ml/kg; B—Fulton's coefficient, a variance analysis of the fish fed with a commercial feed supplemented with the *Paenibacillus alvei* at 2 ml/kg; and C—Fulton's coefficient, a variance analysis of the Control Group, the fish fed with a commercial feed only (no probiotic added).

*A—Fultonov koeficijent, analiza varijance riba hranjenih komercijalnom hranom s dodatkom *Paenibacillus alvei* u dozi od 1 ml/kg; B—Fultonov koeficijent, analiza varijance riba hranjenih komercijalnom hranom s dodatkom *Paenibacillus alvei* u dozi od 2 ml/kg; i C—Fultonov koeficijent, analiza varijance kontrolne skupine, riba hranjenih samo komercijalnom hranom (bez dodanog probiotika).

Experimental Groups A and B, while there was no statistically significant difference between the experimental groups themselves.

The Fulton's condition factor in the Experimental Group A showed the significantly higher values ($p < 0.05$) if compared with the condition factor in the Control Group (1.89 in the Group A and 1.49 in the Group C, being a difference of 0.4, or of 21.17%).

The Fulton's condition factor in the Experimental Group B showed the significantly higher values ($p < 0.05$) if compared with the condition factor in the Control Group (1.85 in the Group B and 1.49 in the Group C, being a difference of 0.36, or of 19.46%).

The fish mass in both Experimental Groups, A and B, showed a statistically significant difference ($p < 0.05$) when compared with the mass values of the Control Group C. The different probiotic concentrations applied in the Experimental Groups A and B did not appear to contribute to a difference in their mass. More precisely, the research results pertaining to a fish mass between the carp in the Groups A and B showed no statistically significant difference.

In this study, Fulton's condition factor, which is a ratio between the body weight (W) and body length (L), was also monitored in the experimental individuals from all three groups. Many studies and research highlight the importance and impact of biotic and abiotic factors, population structure, aquacultural stocking density, diet, and water quality concerning the variations in the fish-growth parameters (Ranjan et al., 2005; Lemma et al., 2015). Fulton's coefficient parameters can be influenced by various factors, including a season, sex, the differences in the individual samples, population density, quality and quantity of food, fish's health condition, and environmental conditions (Moradinasab et al., 2012; Innal et al., 2012; Lemma et al., 2015; Marinović et al., 2015).

During a final control, the results from a determination of Fulton's condition-factor coefficient showed that the condition factor for the Experimental Groups A and B had the mean values of 1.89 and 1.86, respectively, while the value amounted to 1.49 for the Control Group C. In the course of a final control measurement, the analysis of variance showed that a low value of Fulton's coefficient in the Control Group C statistically significantly differed ($p < 0.05$) if compared with the Experimental Groups A and B. The results indicated that the influence of a probiotic on the fish from the Experimental Groups A and B had a positive effect on Fulton's coefficient when compared with the Control Group C, which was not treated with the probiotic in diet.

The results obtained are in accordance with a research of Asadian et al. (2015), who treated the experimental common carp individuals with a combined commercial probiotic. The authors observed the significant positive effects on the weight, length, growth, and Fulton's condition factor, which was increased by 58%. Karatas et al. (2007) found the slightly lower average values of Fulton's condition factor in the carp, at 1.33. The measurement results for the female population ranged from 1.01 to 1.86, while it amounted to 1.27 for the male carp individuals. According to Erdem et al. (1988), the annual level of Fulton's coefficient varies from 1.49 to 2.69.

As one of the main parameters applied to quantify the effect of the applied probiotic in the feed, Fulton's coefficient and the body mass of the farmed common carp in an intensive cage-farming system were the first indicators presenting a positive and continuous increase throughout the entire experimental-rearing process.

CONCLUSION

The research results indicate that the application of the probiotic *Paenibacillus alvei* positively affected the body mass and Fulton's condition factor of the common carp in an intensive cage-farming system. The statistically significant differences between the Experimental Groups (A and B) and the Control Group (C) confirmed the effectiveness of a probiotic feed addition in the improvement of growth parameters. Despite the different probiotic concentrations in the experimental groups, no significant difference in their body mass was detected, suggesting that the presence of a probiotic feed addition, rather than its quantity, was the key factor. Fulton's condition factor was significantly higher in the treated groups if compared with the Control Group, further confirming the probiotic's positive effect on the fish condition. These findings align with the previous research studies, which also reported an improved fish's body-mass growth and carp's condition factor under a probiotic treatment.

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SAŽETAK

Ovo istraživanje obuhvatilo je ribe u dvije eksperimentalne skupine (skupina A primala je nižu koncentraciju probiotika, dok je skupina B primala višu koncentraciju probiotika u hrani). Ribe u kontrolnoj skupini (C) nisu dobivale probiotički dodatak u prehrani. Fultonov koeficijent kondicije i tjelesna masa praćeni su tijekom pet kontrolnih mjerenja. Prosječna tjelesna masa šarana u eksperimentalnim skupinama A i B pokazala je značajno više vrijednosti ($p < 0,05$) u usporedbi s kontrolnom skupinom tijekom svih pet kontrolnih razdoblja. Fultonov koeficijent kondicije u kontrolnoj skupini (C) bio je značajno niži nego u obje eksperimentalne skupine, dok između skupina A i B nije uočena statistički značajna razlika. Ovi rezultati upućuju na to da probiotički dodatci u hrani šarana pozitivno utječu na rast riba i njihovu kondiciju.

Ključne riječi: probiotik, hrana, šaran, akvakultura, tjelesna masa, Fultonov koeficijent