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Original Article

The effect of adding the growth promoter Bio Boost Aqua to fermented diets to improve the dietary value and productive performance of common carp, *Cyprinus carpio* L.

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Abstract: The current study was conducted to evaluate the efficiency of using Saccharomyces cerevisiae and the growth enhancer Bio Boost Aqua to improve the dietary value and productive performance of common carp, *Cyprinus carpio*. For this purpose, 80 fish were used, and water quality parameters were controlled during the experiment, with no mortality. The results showed significant differences between the control group and the three experimental treatments. The results also revealed a significant increase in the total protein content in the fermented diet compared to the control one. Treatments also led to a significant reduction in the fiber content of the fermented diet compared to the control. No significant difference was observed in studied diets for carbohydrates, fat, and ash percentages. There were no significant differences between treatments in the amount of feed consumed. A significant difference for treatments T2 and T3 was observed in growth performance involving final weight and weight gain. The specific growth rate was significantly superior for T2 compared to the other treatments. Feed efficiency showed a significant superiority in this parameter for T2 and T3 compared to T1 and T4 treatment. Protein consumed and protein produced values recorded a significantly superior performance for all treatments compared to the control. The results showed that the percentages of moisture and ash in muscle tissues decreased at the end of the experiment compared to the beginning. A significant difference in the percentage of protein deposited in body tissues for all treatments was observed at the end of the experiment. In contrast, the fat percentage did not show any significant differences in this parameter.

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Introduction

Aquaculture is one of the fastest-growing sectors because it provides high-value food for humans and is important in improving their health (Mirghaed et al., 2018). Therefore, most countries seek stability in food security through developing food-producing sectors, which directly affects those countries' social and economic reality (FAO, 2014). The expansion of aquaculture depends greatly on feeding technology and the cost of feed, which is one of the largest operating costs in this sector (Sultana et al., 2001). Fish is also one of the main sources of protein because it can provide a large portion of food, especially in developing countries (Ochokwu et al., 2014), which provides about 18.5% of animal protein (FAO, 2009, 2022).

One of the most important obstacles facing the development of livestock in general and fish production in particular is the high prices of feed resources, as feeding constitutes about 60% of the total costs (Al-Humairi et al., 2020). Therefore, researchers set out to reduce the cost of feeds, produce alternatives of low-cost feeds with good nutritive value, or use techniques to improve their nutritional value (Maaruf and Akbay, 2020). Thus, managing nutrition regarding components and improving nutritive value is an important aspect of fish farming (Lovell, 2002). Ghosh et al. (2002) indicated that the success of common carp farming depends primarily on the development of diets and the selection and combination of raw materials, which impact growth performance. Many studies have also been conducted on common carp diets to increase growth rates and feed efficiency to reduce production costs by

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improving raw materials or using food additives and growth enhancers (FAO, 2012). Based on this issue, many researchers resorted to conducting some treatments aimed at improving the nutritional value of these feeds to increase their palatability and improve their digestibility coefficient by adding a mixture of enzymes (Malik et al., 2016), chemical supplementations (Hontiveros and Serrano, 2015), or performing fermentation of the feedstuffs using yeasts or fungi. These studies have achieved many positive goals, such as increasing the diet's nutritional value (Ali, 2019).

Fermentation is considered one of the modern processes used to improve feed, enhance the digestibility of feed materials, and increase their nutritional value (Zhang et al., 2016). Recent studies have also shown that fermentation increases the crude protein content and reduces the crude fiber (Sugiharto et al., 2016), as well as reduces anti-nutritional factors in non-traditional feed ingredients, which can reduce feed digestibility (Khempaka et al., 2014). The fermentation method relies on the use of beneficial bacteria or fungi to convert food materials into substances that are more easily digestible and nutritionally beneficial (Canibe and Jensen, 2012). Radwan (2014) showed the possibility of improving the nutritional value of soybean meal through fermentation, which led to an increase in protein content and a decrease in the percentage of trypsin inhibitor and phytic acid. Also, the feed cost was reduced by 16.02% compared to unfermented feed. However, Francis et al. (2001) mentioned that one of the most important disadvantages of feed ingredients from plant sources is the presence of anti-nutritional factors, which may negatively affect fish growth performance and can be improved through fermentation.

Feed additives in fish diets play an effective role in growth (El-Sayed, 2002), producing a high nutritive value (Nates, 2016). Most feed additives are non-nutritious and include antibiotics, immune stimulants, probiotics, prebiotics, and antioxidants (Kord et al., 2020). The diet fortified with yeast extract causes an increase in growth rates and feed efficiency (Hassaan et al., 2018). Among these recently produced unconventional additives is Bio Boost Aqua yeast extract (BBA), considered one of the modern feed additives that improves the body's immune response and protects against stress from adverse environmental conditions. It also increases growth by enhancing feed consumption and improving the feed conversion ratio. Al-Janabi et al. (2022) stated that Bio Boost (BBA) is an extract of the outer cell wall of the yeast *Saccharomyces cerevisiae*, which contains crude protein, fibers, mannan oligosaccharides, and beta-glucans. These beneficial compounds improve the immune response, adjust the intestinal microflora balance, increase growth performance, and reduce stress conditions. Therefore, the current study evaluated the efficiency of using *S. cerevisiae* and the growth enhancer Bio Boost Aqua to improve the dietary value and productive performance of common carp, *Cyprinus carpio*.

Materials and Methods

The study was conducted in the Fish Nutrition Laboratory of the Department of Animal Production Techniques, Al-Musaib Technical College, Al-Furat Al-Awsat Technical University, Babylon. It lasted 60 days from September 1st, 2022, except for the adaptation period, which was 14 days. The fish were reared using the recirculation system, which consisted of eight glass (150-liter) tanks with dimensions 100 × 40×50 cm.

Eighty common carp were used, with an average starting weight of 36.35 gr, obtained from a private farm in Babylon Governorate. The fish were distributed at a rate of 10 per pond, with two replicates for each treatment, considering that the fish weights were as close as possible in all experimental units. The fish were fed 3% of their wet body weight during the experiment twice daily. The fish weighing was conducted every two weeks. Some environmental factors of the water in the ponds were measured during the experiment, including temperature (°C), dissolved oxygen concentration (mg/L), salinity (%), and pH.

Diets preparation: Four diets were prepared by mixing the components of each diet separately until they were homogeneous. The feed was ground well with an electric grinder, and then the four diets were formed, three of which had baker's yeast added at a rate of 0.5 gm/kg, and water was added to form a dough. After that, the three experimental diets were fermented for 48 hours following the method of Radwan (2014). Once the three diets were fermented, they were dried thoroughly. Two were ground well, and Aqua Bio Boost was added to them in the proportions specified in Table 1. Subsequently, they were fed into the manual meat grinding machine to form pellets with a 2-3 mm diameter suitable for the size of the experimental fish's mouths. The pellets were dried at room temperature for 72 hours, then stored in polyethylene bags labeled with the name of the treatment and kept in the refrigerator at 4°C until used.

The diets were formulated based on treatments and distributed as follows: (T1) a control diet without any treatment, (T2) a fermented diet for 48 hours using *S. cereviseae* at a rate of 0.5 g/ kg, (T3) a fermented diet supplemented with 0.5 g/kg of the growth promoter (Bio Boost Aqua), and (T4) a fermented diet supplemented with 1 g/kg of the growth promoter (Bio Boost Aqua).

Growth parameters: Feed intake during growth experiments was estimated daily as a percentage of body weight for each treatment. Total weight gain (TWG) and daily weight gain (DWG) values were calculated according to Sevier et al. (2000), and the specific growth rate (SGR) of the experimental fish was determined based on the method described in Cruz et al. (2014). Utilizing the values of food intake and weight gain along with the results of the chemical analysis of the components of fish bodies, the feed conversion ratio (FCR), feed conversion efficiency (FCE), protein intake (PI), and Protein Efficiency Ratio (PER) were calculated following Tacon (1990).

Chemical analyses of diets and fish bodies: The percentages of moisture, crude protein, fat, ash, and fiber in experimental diets and fish meat were measured before and after the experiment, following the AOAC (2000).

Statistical analysis: The statistical analysis was performed using a completely randomized design (CRD) with the Statistical Analysis System (SAS, 2001). Significant differences between the means of traits were assessed using the Duncan test (1955) at a significance level of 0.05.

Table 1. Ingredients of experimental diets and their percentage used in the feed of common carp.

Ingredients (%)	Experimental treatments			
	T1	T2	T3	T4
Vegetable protein concentrate	10	10	10	10
Fish meal	5	5	5	5
Soybean meal	40	40	40	40
Wheat flour	14	14	14	14
Yellow corn	10	10	10	10
Rice polishing	10	10	10	10
Wheat bran	10	10	10	10
Premix	1	1	1	1
Saccharomyces cereviseae	-	0.05	0.05	0.05
Bio Boost Aqua	-	-	0.05	0.1

Results

Environmental factors: Table 2 presents some environmental factors in the laboratory water where the experiment was conducted. The results indicated that the water quality measurements (temperature, dissolved oxygen, salinity, and pH) monitored and measured during the study period remained relatively stable and within levels suitable for fish life, with no fish mortality recorded during the experiment.

Experimental diets: Table 3 displays the results of the analysis of the chemical composition of the formulated diets. A higher moisture content was observed in the three experimental diets compared to the control treatment. The results showed a significant improvement ($P<0.05$) and an increase in the percentage of crude protein in the three experimental treatments compared to the control treatment. Additionally, a significant decrease ($P<0.05$) in the percentage of crude fiber in the fermented diets was observed compared to the control treatment, where the fiber increased by 12.91%. The results did not reveal significant differences in the percentages of carbohydrates, fat, and ash for the four diets studied in the feeding experiments.

Total mean weights and weight gain: Table 4 indicates no significant differences ($P\geq0.05$) in the initial live weight in the growth performance that

Table 2. Some environmental factors of rearing pond water during experiments (mean±SD).

Environmental factors	Weeks				Total mean
	2 - 1	4 -3	6 - 5	8 -7	60 days
Temperature (°C)	29.5±0.5	27±1.0	24.5±0.5	23.16±0.76	26.04±2.60
Dissolved oxygen (mg/L)	6.1±0.55	7.27 ±0.24	7.5±0.1	7.67±0.32	7.15±0.67
pH	7.10±0.26	7.21±0.3	7.43±0.15	7.20±0.43	7.23±0.29
Salinity (ppt)	0.5±0.01	0.60±0.01	0.56±0.004	0.46±0.01	0.55±0.05

Table 3. Actual chemical composition (%) of experimental diets based on dry weight (mean±SD).

Chemical composition%	Treatments			
	T1	T2	T3	T4
Moisture	6.26±0.04b	7.72±0.55a	7.165±0.04a	7.05±0.06a
Crude protein	28.88±0.30b	31.87±0.04a	31.36±0.48a	31.11±0.09a
Ether extract	5.17±1.11a	5.57±0.61a	7.07±0.35a	6.55±0.39a
Ash	5.09±0.29ab	4.38±0.12b	5.29±0.22ab	5.98±0.65a
fiber	12.91±0.40a	7.36±0.57b	5.96±1.18b	6.78±0.14b
Nitrogen free extract	41.67±1.57a	43.08±0.67a	43.15±0.88a	42.51±0.24a

Different letters in the same row indicate significant differences ($P≤0.05$) among treatments.

Table 4. Growth parameters of common carp fish during growth experiments in different treatments (mean±SD).

Studied attributes	Treatments			
	T1	T2	T3	T4
Initial weight (g)	36.05±0.07a	36.3±0.08a	36.55±0.07a	36.51±0.14a
Final weight (g)	51.4±0.14c	57.25±0.35a	54.45±1.20b	52.05±0.21c
Total weight gain (g)	15.35±0.07c	20.95±0.35a	17.91±1.13b	15.55±0.35c
Specific growth rate (%/day)	46.07±4.82b	53.44±5.05a	39.99±10.27b	34.67±6.86b
Daily growth rate (g/day)	0.59±0.001c	0.75±0.009a	0.66±0.03b	0.59±0.012c

Different letters in one row indicate significant differences ($P≤0.05$) among treatments.

lasted for 60 days. However, significant differences ($P≤0.05$) were observed in the final live mass and the total weight gain for T2 and T3 compared with the control treatment and T4.

Notably, there was a decrease in the total and daily weight gain in treatment T4, despite the increase in the percentage of Bio Boost to double that of treatment T3. Significant differences ($P≤0.05$) in the specific growth rate (SGR) were observed in T2, while the average daily weight gain showed significant superiority in T2 and T3 at rates of 0.75 and 0.66 g/day, respectively, compared to the control treatment and T4.

Feeding efficiency: Although there were no significant differences in the amount of feed consumed by the experimental fish (Table 5), the results showed a significant superiority ($P<0.05$) in T2 and T3 in the values of the feed conversion efficiency factor and ratio, as well as in the values of protein intake (PI) (g/fish). These two treatments achieved higher values than the control treatments, T1 and T4. The protein utilization efficiency ratio (PER%) and protein produced value (PPV%) recorded a significant increase at the level of ($P<0.05$) in favor of the T3 and T4 treatments.

Chemical composition of fish meat: Table 6 presents the chemical composition of fish meat before and after the experiments. Significant differences ($P≤0.05$) were observed in the moisture content before and after the experiment among the different treatments (Table 4). The body protein content significantly increased ($P≤0.05$) compared to the protein content at the beginning of the experiment for all treatments, with treatments T3 and T4 recording higher values amounting to 19.03% compared to the other treatments. No significant differences were found in the body content of crude fat. A decrease ($P≤0.05$) in the percentage of ash was observed in fish fed on

Table 5. Feed efficiency measures (feed conversion coefficient, feed conversion efficiency, protein efficiency ratio, and produced protein value) for common carp fish during growth experiments (mean±SD).

Traits	Treatments			
	T1	T2	T3	T4
Feed intake (g/fish)	84.58±0.13a	87.62±2.25a	86.59±0.53a	84.87±0.88a
Feed conversion coefficient	5.51±0.01c	4.18±0.03a	4.84±0.27b	5.45±0.18c
Feed conversion efficiency (%)	18.14±0.038c	23.91±0.21a	20.66±0.833b	18.32±0.429c
Protein intake (g/fish)	18.14±0.05c	23.91±0.21a	20.66±1.17b	18.32±0.60c
Protein efficiency ratio (%)	46.90±1.10b	47.44±0.92b	49.30±0.78ab	50.54±0.73a
Produced protein value (%)	4.65±0.77c	6.75±0.08b	9.91±0.09a	10.31±0.90a

Different letters in the same row indicate significant differences ($P \leq 0.05$) in traits between groups.

Table 6. The chemical composition of common carp fish (%) in the different treatments before and after the experiment was based on the wet weight (mean±SD).

Components (%)	Before starting of experiment (%)	After finishing the experiment (%)			
		T1	T2	T3	T4
Moisture	74.19±0.04a	73.15±0.13b	73.0±0.007b	73.02±0.01b	72.93±0.13b
Crude protein	16.64±0.042c	18.07±0.28b	18.47±0.45ab	19.031±0.07a	19.037±0.02a
Crude fat	4.32±0.007a	4.24±0.59a	4.19±0.23a	4.07±0.02a	4.06±0.04a
Ash	4.84±0.098a	4.53±0.16ab	4.24±0.23bc	4.06±0.01c	4.07±0.07c

Different letters in the row indicate significant differences ($P \leq 0.05$) among groups.

fermented diets.

Discussions

Environmental conditions: Fish farming requires ideal environmental conditions for the species to thrive. The results of various environmental factors recorded during the study period indicated that they were within appropriate limits for the living and growth of common carp fish (Goran et al., 2021). These conditions significantly affect the nutritional metabolic rates of the fish body, especially water temperature, which directly influences metabolic and feeding rates (Anwar, 2013).

Diets: Fish feeds represent a significant portion of production costs. Research aims to reduce this cost by exploring new alternatives and technologies to produce low-cost feeds with high nutritional value. This can involve replacing or partially adding feed components, utilizing yeasts, growth promoters, and modern manufacturing methods (Maaruf and Akbay, 2020). Fermentation is a modern method for enhancing nutrient quality in feed components by improving digestibility and increasing nutritional value (Zhang et al., 2016).

The analysis of feed results revealed a higher protein percentage in fermented diets compared to the control diet. This increase may be attributed to the fermentation action by baker's yeast and Bio Boost. Fermentation is crucial for breaking down large organic molecules into smaller ones through microbial action. Yeast enzymes play a role in converting proteins into peptides and amino acids (Nkhata, 2018). Fermentation leads to biochemical changes that enhance protein and essential amino acid content in food components (Xiang et al., 2019), increasing crude protein content in food diets (Khempaka et al., 2014).

The high protein content in diets T4, T3, and T2 may be due to adding baker's yeast and Bio Boost Aqua yeast wall, both rich in protein. Prolonged fermentation further boosts protein levels by accelerating biomass formation from microorganisms. Studies have shown that adding yeast extracts increases crude protein content in diets (Hassaan et al., 2018). Additionally, *S. cerevisiae* yeast has been found to enhance crude protein content in diets compared to control diets (Abdurrahman et al., 2015).

The study also revealed a decrease in crude fiber content in T4, T3, and T2 compared to the control diet, possibly due to the action of cellulase enzymes produced by yeast. These enzymes break down cellulose into glucose, providing the energy necessary for yeast growth. *Saccharomyces cerevisiae* produces cellulase enzymes that break down cellulose, reducing crude fiber and enhancing nutrient availability (Dimovelis et al., 2004). Furthermore, fermentation reduces crude fiber content in feed ingredients, with yeasts converting low-value feed biomass into high-value components at low costs while inhibiting anti-nutritional factors in feed components (Lapeña et al., 2020; Khempaka et al., 2014).

Growth and feeding efficiency parameters: Growth standards are essential scientific benchmarks for evaluating feed quality and protein levels (Hepher, 1988) and are commonly used to assess the nutritional efficiency of fish feeds (Taher and AL-Dubakel, 2020). The current study's growth standards revealed that common carp fed experimental diets subjected to fermentation treatments with baker's yeast and the addition of Bio Boost (BBA) led to significant improvements in growth parameters (final weight, total and daily weight gain, specific and daily growth rate) for T2 and T3. These percentages of baker's yeast and

Growth enhancers can stimulate the growth of common carp fish by enhancing enzymatic secretions in the stomach and regulating the digestion process (Al-Neamy, 2008). Baker's yeast improves digestion by stimulating digestive enzyme production or altering the intestinal environment, increasing growth rates (Welker and Lim, 2011). The fermentation process aids in breaking down large molecules into simpler ones through microbial action, with yeast enzymes converting sugars and starches into alcohol and proteins into peptides and amino acids (Nkhata, 2018). Fermentation reduces anti-nutritional factors like protease inhibitors and enhances soybean meal's free amino acid and peptide contents (Zhang et al., 2016). Increasing the Bio Boost percentage to 1 g/kg in fermented diets decreased the growth standards studied, as supported by Hauptman et al. (2014), who noted negative effects on weight gain and fish growth with higher yeast percentages in fish diets.

The feed conversion rate (FCR), which indicates the relationship between feed consumption and weight gain, is a crucial criterion for measuring food efficiency (Al-Hamadany, 2008). Statistical analysis results indicated a significant improvement in FCR in treatments T2 and T3 compared to T1 and T4, which had higher values. This improvement may be attributed to the optimal use of appropriate levels of baker's yeast in the fermentation process and the growth enhancer in T2 and T3. These findings align with Goda et al. (2011), who demonstrated superior feed conversion ratios when using baker's yeast and digestive enzymes in Nile tilapia fingerlings' diets. Yeasts enhance the feed conversion coefficient by increasing the production of digestive enzymes for starches, proteins, and fats, improving the digestion process and feed component utilization. This increases feed efficiency and feed conversion ratios (Selim and Reda, 2015). Yeasts also boost the intestine's inner layer absorption capacity, maximizing nutritional element utilization from consumed feed (El-Haroun et al., 2006). Fermentation results in beneficial biochemical changes in food components, enhancing protein content, essential amino acids, vitamins, anti-nutrients, and feed palatability (Xiang et al., 2019).

The feed conversion efficiency (FCE) percentage is crucial as it reflects fish proficiency in utilizing feed materials (Ghosh et al., 2007) and represents the overall feed utilization (Manning and Gibson, 2004). The FCE results in the current study indicated significant differences ($P \leq 0.05$) among fishes fed on T2 and T3 compared to T4 and the control treatment. The superiority of T2 and T3 is attributed to the role of baker's yeast in the fermentation process, enhancing the activity of the natural growth booster (Bio Boost Aqua) in T3. This aligns with Canibe and Jensen (2012), who noted that fermentation by baker's yeast helped reduce the quantity of feed additives in diet contents.

The two standards of protein intake and protein efficiency ratio are studied to clarify the relationship between weight gain and the amount of protein intake. They are used to evaluate feed protein and the feed itself. The results of the current study demonstrated that T2 was significantly superior to T1, T3, and T4 in protein intake, aligning with the findings of De Rodriganez et al. (2009) during feeding Senegalese sole fish on diets containing *S. cerevisiae* for 61 days compared to fish fed yeast-free diets. This superiority is attributed to the effective role of baker's yeast in enhancing nutrient quality in feed composition, thereby improving nutrient digestibility and increasing nutritional value (Zhang et al., 2016).

Regarding the measure of protein utilization efficiency, the current study results indicated that T3 and T4 were significantly superior ($p<0.05$) compared to T2 and the control treatment, consistent with the study conducted by de Azevedo et al. (2016) by adding a growth booster MOS type (Mannan Oligo Saccharides) with *Bacillus subtilis* to the diet of Nile tilapia (*O. niloticus*) fish. The synergistic effect of these additions led to superior protein efficiency ratios compared to the control diet. Studies suggest that when yeasts are combined with growth enhancers, the synergistic effect aids in enzyme secretion that enhances digestion (Arangdhar et al., 2015) and improves weight gains in fish fed the mixture (Lee et al., 2015). Growth enhancers also modulate intestinal microflora and enhance intestinal villi integrity (Safari et al., 2014).

Regarding Protein Produced Value (PPV) values, the results indicated higher PPV values in common carp fish-fed mixtures (T3 and T4), amounting to 9.91% and 10.31%, compared to fish in T1 and T2 treatments. This is attributed to the high protein content in Bio Boost Aqua (BBA), enabling common carp fish to deposit protein in the body more efficiently than in other treatments. These findings align with the study of Sagada et al. (2021) on young black sea bream (*Acanthopagrus schlegelii*) fed *Lactobacillus plantarum* and selenium and are supported by Ghosh et al. (2005), who noted that yeast extract increases protein production in fish body mass.

Chemical composition of fish meat: The high percentage of crude protein in the body composition of fish-fed diets containing yeasts can be explained by the active role of these yeasts in secreting protease and peptidase by *S. cerevisiae*. Additionally, adding the growth booster (Bio Boost) to diets stimulates the secretion of digestive enzymes, enhancing protein digestion and absorption (Ghosh et al., 2005). These enzymes break down large food molecules into smaller, more easily digestible organic molecules, leading to higher protein content in the body (Bagheri et al., 2008).

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