# Effects of Different Feed Additives on Growth and Water Quality of Koi Carp

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Abstract: In this experiment, koi carp was used as the experimental object. The effects of the 2% Guar gum (GG), 2% sodium carboxymethyl cellulose (CMC), and 2% sodium polyacrylate (SP) on the growth performance and aquaculture water quality of Koi carp were studied by adding additives to the basic feed. The results showed as follows: Compared with the control group, the final body weight ($W_f$), weight gain rate (*WGR*) and specific growth rate (*SGR*) were significantly increased after adding 2%GG, 2%CMC, and 2%SP ($P < 0.05$). In addition, all three additives can reduce the *FCR* value. The concentrations of nitrite and ammonia in the experimental group supplemented with 2% Guar gum, 2%CMC and 2% SP were significantly lower than those in the control group ($P < 0.05$). The concentrations of nitrite and ammonia in the 2% Guar gum group were the lowest ($P < 0.05$). At the late stage of the experiment, the concentrations of nitrite and ammonia in the 2% GG group were significantly lower than those of 2% CMC ($P < 0.05$). The results showed that adding 2% GG to the diet was more beneficial to the growth of Koi carp and the regulation of aquaculture water quality.

## 1 INTRODUCTION

Koi is favored by consumers because of its bright body color, body shape and varied pattern. With the rapid development of the ornamental koi breeding industry, a new breeding model of factory production has been formed. In order to achieve economic efficiency, farmers usually use the efficient feeding method. However, a large amount of feed is put into the breeding tank, so that the feed is dissolved in the water, which will cause eutrophication of the water body. In addition, high-frequency feeding will increase the excrement of fish, causing pollution of aquaculture water bodies, prone to diseases, not only causing economic losses but also seriously affecting the ecological environment. Therefore, efficient feeding should not only meet the requirements of increasing the growth rate of koi, but also reduce the pollution of the water body by the feed itself and the excrement of the fish.

Guar gum, sodium carboxymethyl cellulose, and sodium polyacrylate are three additives which have the functions of thickening, emulsifying, bonding, stabilization, and improving adhesion. These three additives are non-toxic and harmless and have a wide range of uses in food processing, factory production, medical and pharmaceutical, and many other aspects (Gu, 2010; Li, 2018). However, there is less research on the application of these three additives in aquatic animal feed (Shen, 2017; Shen, 2019). Therefore, this experiment studied the effects of these three additives on the growth of koi and the quality of aquaculture water by adding these three additives to the feed, in order to provide a theoretical basis for solving the problem of water pollution caused by bait residues and provide a reference for the research and development of low-pollution feed for koi.



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# 2 MATERIALS AND METHODS

## 2.1 Experimental Design

The koi used in this experiment were from Beijing Yashi Koi Culture Technology Co., Ltd. In this experiment, 360 koi carps with the same specifications and healthy and harmless were selected. The experiment was carried out in Xiaotangshan Breeding Base of Beijing Fisheries Science Institute. The koi were divided into 4 groups, each group was set up with three parallels, and 30 fish were placed in each parallel. The composition of the experimental diet is shown in Tab. 1. Three different binders were added to the basal feed: 2% GG, 2% CMC and 2% SP. Guar gum, respectively, to study the effect of seed adhesive on the growth performance and aquaculture water quality of koi carp.

Table 1: Ingredient composition of experimental diets %.

| Ingredients | additive amount |
|---|---|
| Fish meal | 15 |
| Soybean meal | 30 |
| Rapeseed meal | 15 |
| Wheat flour | 20 |
| Wheat bran | 5.4 |
| Soybean oil | 2 |
| Fish oil | 2 |
| Premix | 1.3 |
| Choline oxide | 0.3 |
| Rapeseed meal | 9 |

## 2.2 Indicator Measurement Method

Determination of fish body weight, body length, specific growth rate (*SGR*), weight gain rate (*WGR*), feed coefficient (*FCR*) and Survival rate (*SR*) and other indicators were listed as follows. A portable water quality monitor was used to monitor dissolved oxygen, water temperature and pH, Ammonia nitrogen and nitrite in aquaculture water were measured in the laboratory.

$$SR = 100\% \times S_t/S_0 \quad (1)$$

$$WGR = 100\% \times (W_t - W_o)/ W_o \quad (2)$$

$$SGR = 100 \times [\mathrm{Ln}(W_t)-\mathrm{Ln}(W_o)]/ t \quad (3)$$

$$FCR = C/ (W_t+W_d-W_o) \quad (4)$$

In the above formula: $S_t$ is the number of surviving fish at the end of the experiment, $S_o$ is the number of initial fish; $W_o$ is the initial body weight of the fish, $W_t$ is the final body weight, $W_d$ is the total weight of the dead fish (g); $t$ is the number of days of experiment ($d$); $C$ is food intake.

## 2.3 Data Processing and Analysis

One-way ANOVA was conducted on the experimental data using STATISTIC 7.0 statistical software, and Duncan's method was used to test the significance of difference, and the significance level was $P<0.05$.

# 3 RESULTS

## 3.1 Effects of Three Additives on The Growth Performance of Koi Carp

As can be seen from Tab. 2, the average initial body weight of experimental fish was 75.47-79.33 g, and there was no significant difference among all groups ($P > 0.05$). The $W_t$, *WGR* and *SGR* of the experimental group were significantly higher than those of the control group after adding 2% GG, 2% CMC and 2% SP. The *WGR* and *SGR* indexes of 2%CMC and 2%GG were significantly higher than those of 2% SP group. All three adhesive groups can reduce the *FCR* value.

Table 2: Survival and growth performance of different groups for Koi carp.

| Index | Control group | 2%GG | 2%CMC | 2%SP |
|---|---|---|---|---|
| $W_o$ | $78.64\pm3.22^{a}$ | $75.47\pm5.43^{a}$ | $76.49\pm7.28^{a}$ | $79.33\pm5.24^{a}$ |
| $W_t$ | $167.22\pm8.99^{d}$ | $189.58\pm10.22^{b}$ | $194.83\pm13.57^{a}$ | $174.89\pm18.27^{c}$ |
| *WGR* | $112.69\pm9.42^{c}$ | $151.27\pm12.45^{a}$ | $154.78\pm10.03^{a}$ | $120.49\pm15.23^{b}$ |
| *SGR* | $1.27\pm0.58^{c}$ | $1.53\pm0.31^{a}$ | $1.55\pm0.07^{a}$ | $1.32\pm0.36^{b}$ |
| *FCR* | $1.38\pm0.14^{a}$ | $1.33\pm0.21^{a}$ | $1.35\pm0.24^{a}$ | $1.35\pm0.33^{a}$ |
| *SR* | 100 | 100 | 100 | 100 |

### 3.2 Effects of Three Adhesives on Nitrite Content in Aquaculture Water

As can be seen from Fig. 1, the nitrite concentrations in the experimental group supplemented with 2%GG, 2%CMC and 2% SP were significantly lower than those in the control group ($P < 0.05$). In the first 10 days of experiment, the 2% GG and 2% CMC groups had no significant effect on the concentration of nitrite in aquaculture water ($P > 0.05$). After 12 days, the concentration of nitrite in 2% GG supplemental group was significantly lower than that in 2% CMC supplemental group ($P < 0.05$).

### 3.3 Effects of Three Additives on Ammonia in Aquaculture Water

As can be seen from Fig. 2, the ammonia concentration in the experimental group supplemented with 2% GG, 2% CMC and 2% SP were significantly lower than that in the control group ($P < 0.05$), and the ammonia concentration in the 2% GG supplemental level group was the lowest ($P < 0.05$). In the first 10 days of the experiment, there was no significant difference in ammonia concentration between the experimental treatment groups and the control group ($P > 0.05$). After 24 days, the ammonia concentration of the 2% GG group tended to decrease.

## 4 DISCUSSION

The main feed of koi carp is pelleted. In the production of pelleted feed, its stability in water has been a wide concern. If the adhesion of feed is improved, a certain proportion of adhesive can be added in the process of making the feed to increase the viscosity of feed, which is helpful to feed molding and reduce the dissolution of feed in the water. In fish feed, adhesive plays an important role in water stability of fish feed. There are two main types of adhesives: synthetic chemicals and natural substances. The natural substances are mainly derived from extracts of animals, land plants, and seaweed. GG is a feed additive extracted from Guar bean by special processing technology, which is relatively mature in domestic and foreign research and application (Zhu, 2002; Muna-Ahmed M M, 2000). CMC is a chemically synthesized adhesive, which has developed rapidly in recent years. CMC is also a kind of water-soluble polymer cellulose ether, which is granular powder or white fiber, odorless and tasteless, and its aqueous solution is extremely unstable to heat. In addition, CMC has no nutritional

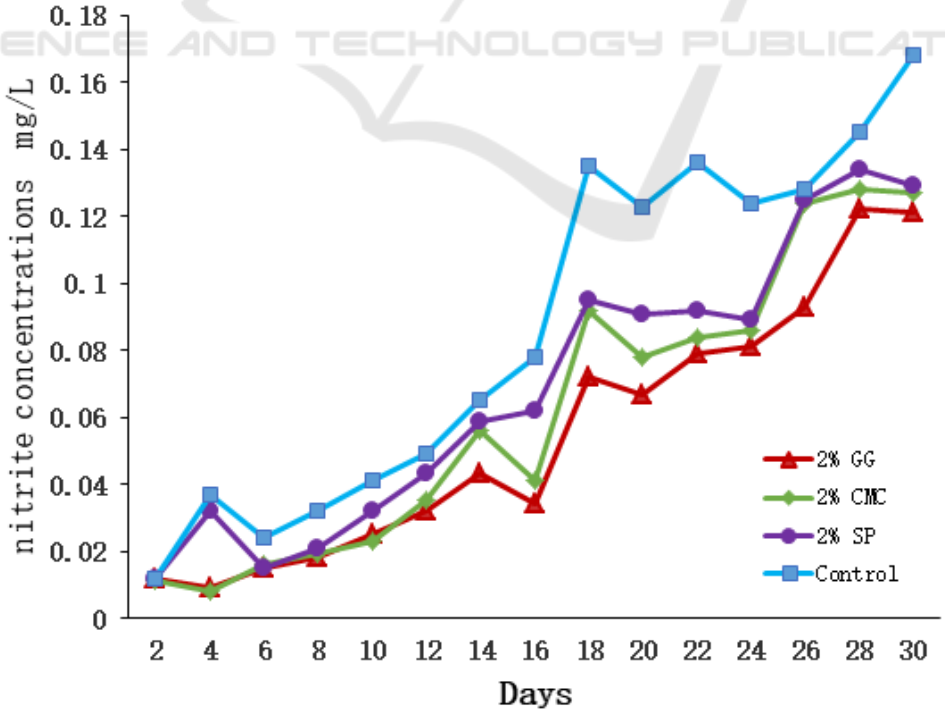


Figure 1: Effects of three additives on nitrite content of the water body.

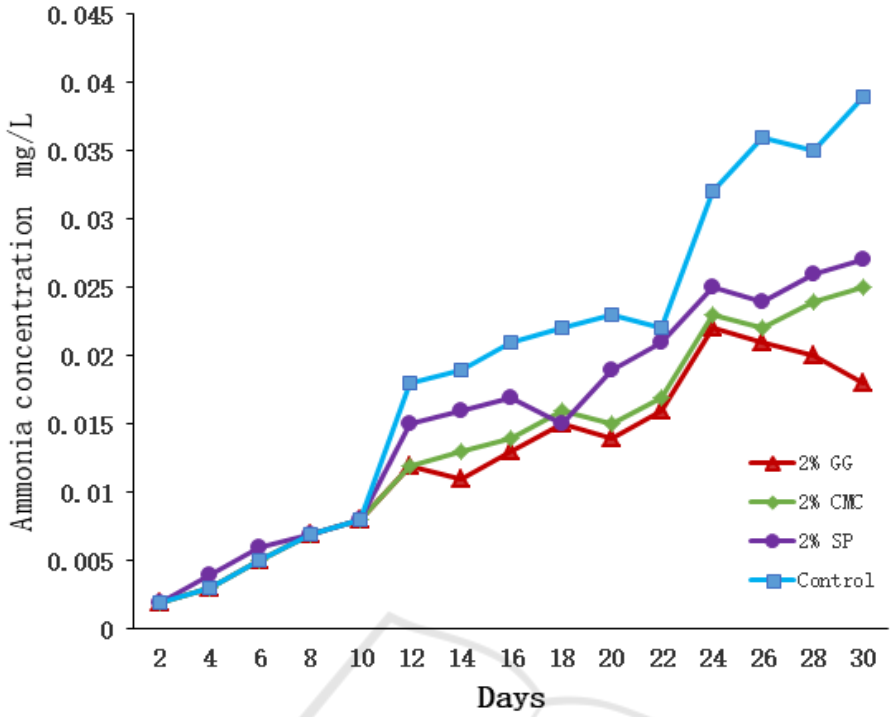


Figure 2: Effects of three additives on ammonia content of the water body.

components, and mainly plays the role of adhesion. Previous studies have proved that the addition amount of CMC in fish feed should not be more than 2% (Xiao, 2016). Therefore, in this study, 2% was also selected for CMC. It has been proved by experiments that CMC has similar properties to sodium alginate, good water holdup and certain ductility resistance (Luo, 1998). SP is a high polymer electrolyte, colorless water-soluble transparent resin, which can be used as food additives and widely used in animal feed. Xue *et al*. (Xu, 2005) reported that it can effectively prevent gastric ulcer disease in pig feed. It can be seen that sodium polyacrylate as a feed additive in livestock and poultry feed also has an effect on disease prevention.

In this experiment, 2% CMC addition had the most significant effect on the final body weight of koi, indicating that the addition of CMC adhesive could promote the weight gain of koi and play an important role in promoting the feed digestion and transformation of koi. Li *et al*. (Li, 2008) reported that adding CMC could improve the nitrification ability of post-weaning piglets. It has been shown that the addition of CMC adhesive facilitates the digestion of protein in piglets, and similar favourable results were obtained in this study. CMC adhesives are rarely used in livestock and poultry feeds, mainly due to the increased lignification of the CMC cell wall. Long-term feeding will affect the digestive system of livestock and poultry, thus affecting the ability of digestion and absorption. However, no adverse effects of CMC on the fish digestive system have been reported in aquatic feeds. In addition, CMC is usually weakly alkaline, which can regulate the pH value of fish to a certain extent.

In aquaculture, the main source of nitrogen input is feed. Previous studies have shown that the proportion of nitrogen input from feed that can be stored and utilized by fish generally does not exceed 50% (Chai, 2013; Penczak T, 1982), and the remaining 50% or more nitrogen is released into the aquaculture system as aquaculture waste, resulting in the deterioration of water bodies. The study of Krom *et al. (*Krom M D, 1989) on brackish and Marine fish farming with different densities (6 fish /$m^2$ and 10 fish /$m^2$) proved that the proportion of nitrogen input due to feed was 88% and 99%, respectively. Daniels *et al*. (Daniels H V, 1989) showed that the nitrogen brought in by feed accounted for 84.3%~92.7% of the total nitrogen input in the pond in the common soil culture system. It can be seen that feed contributes a higher proportion of nitrogen content to the aquaculture system. Ammonia nitrogen in aquaculture water may be harmful to fish, and higher concentrations of ammonia nitrogen may even lead to fish death. Some scholars believe that when the concentration of non-ionic ammonia accumulated in water reaches a certain concentration, it will cause damage to fish epidermal

cells, thereby reducing the immunity of fish (Xu, 2015). In this experiment, the ammonia concentration of the experimental group supplemented with 2% GG, 2% CMC and 2% SP are significantly lower than that of the control group, and the ammonia concentration of the 2% GG addition group has a tendency to decrease significantly after 24 days. In addition, the concentration of nitrate in the treatment group supplemented with 2% GG, 2% CMC and 2% SP were significantly lower than that in the control group.

## 5 CONCLUSIONS

In this study, the effects of the 2% Guar gum (GG), 2% sodium carboxymethyl cellulose (CMC), and 2% sodium polyacrylate (SP) on the growth performance and aquaculture water quality of Koi carp were studied. Our results showed that the GG has a good bonding effect on feed, reduces the dissolution rate of feed in the water, and also has the effect of reducing nitrite in water.

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