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# THE EFFECT OF DIFFERENT RATIOS OF FISH BYPRODUCTS ADDED TO FROZEN AND DRIED ARTEMIA ON SOME FEEDING PARAMETERS AND PROTEIN CONTENT IN COMMON CARP *(CYPRINUS CARPIO L.)*

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## ABSTRACT

**The experiment was conducted in the Fish Laboratory for Postgraduate Studies at the University of Baghdad, College of Agricultural Engineering Sciences. A total of 140 fish were used and reared for 70 days. The fish were randomly distributed into seven experimental groups. These groups included the addition of dried Artemia to the second, third, and fourth groups at a rate of 50% of fishmeal powder. Fish internal organ powder was added to the third and fourth groups at rates of 25% and 50%, respectively, of fishmeal powder. Frozen Artemia was also added to the fifth, sixth, and seventh groups at a rate of 50% of fishmeal powder, and fish internal organ powder was added to the sixth and seventh groups at rates of 25% and 50%, respectively, of fishmeal powder. The results showed that Treatment T6 exhibited superiority in feed conversion efficiency, feed intake, feed conversion ratio, apparent digestibility coefficient of the diet, apparent digestibility coefficient of protein, protein intake, and fecal appearance time. This indicates better utilization of added food, especially frozen Artemia at 50%, and fish by-products (internal organs) at 25%. Therefore, it can be concluded that using frozen and dried Artemia at 50% and fish by-products (internal organs) at 25% can be a good alternative to imported fishmeal in the feeding of common carp, contributing to the improvement of the studied traits.**

**Keywords:** Artemia, Fish by-products, Feed conversion efficiency.

# تأثيراستعمال نسب مختلفة من مخلفات الأسماك (الاحشاء الداخلية ) المضافة الى الارتيميا المجمدة والمجففة في بعض معايير تقيم العليقة والبروتين لاسماك الكارب الشائع (*Cyprinus carpio* L.)

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## الخلاصة

**أجريت التجربة في مختبر الأسماك للدراسات العليا/ جامعة بغداد / كلية علوم الهندسة الزراعية، أذ أستعملت 140 سمكه وتم استزراعها لمده 70 يوم. وزعت الاسماك عشوائيا على سبع معاملات اذ تضمنت هذه المعاملات، اضافة الأرتيميا المجففة إلى المعاملة الثانية والثالثة والرابعة بنسبة 50٪ من مسحوق السمك وأضيف مسحوق الاحشاء الداخلية للاسماك الى المعاملة الثالثة والرابعة بنسبة 25% و50% على التوالي من مسحوق السمك وأضيف الأرتيميا المجمدة إلى المعاملة الخامسة والسادسة والسابعة بنسبة 50٪ من مسحوق السمك واضيف مسحوق الاحشاء الداخلية للاسماك الى المعاملة السادسة والسابعة بنسبة 25% و50% من مسحوق السمك على التوالي أظهرت النتائج تفوق المعاملة T6**

[*]**The article is taken from the master's thesis of the first researcher .**

في كفاءة التحويل الغذائي وكمية العلف المتناول ونسبة التحويل الغذئي وكذلك معامل الهظم الظاهري للعليقة ومعامل الهظم الظاهري للبروتين وكمية البروتين المتناول وزمن ظهور الفضلات وهو دليل استفادة الأسماك من الغذاء المضاف اليه الارتيميا المجمدة 50%عن مسحوق السمك ومخلفات الأسماك ( الأحشاء الداخلية ) 25% تلتها المعاملة T3 المضاف اليها 50% ارتيميا مجففة عن مسحوق الاسماك المستورد ومخلفات الاسماك (الاحشاء الداخلية ) 25% عن مسحوق الاسماك المستورد . تستنتج من الدراسة إمكانية استعمال الارتيميا المجمدة والمجففة بسبة 50% ومخلفات الأسماك (الاحشاء الداخلية ) بسنبة 25% بديلا عن مسحوق الاسماك المستورد في علائق أسماك الكارب الشائع كمصدر للبروتين الحيواني لكونه أسهم في تحسين الصفات المدروسة.

**الكلمات المفتاحية** : ارتيميا ، مخلفات الأسماك، كفاءة التحويل الغذائي.

## INTRODUCTION

Fish are considered one of the primary sources of proteins, vitamins, and minerals, surpassing other animal sources in terms of protein content in their meat **(Mahmoud &Al-Khshali, 2022).** The protein in fish is characterized by being simple, easy to digest, and metabolize **(Al-Hilali & Alkhshali, 2019).** and fish is one of the cheapest species of meat compared to other meats because it is available from natural fisheries as it lies its costs in fishing and marketing operations **(Al-Sadoon& Al-Khashali**,**2015**). Fish are a rich source of essential nutrients, including proteins, fats, fat-soluble vitamins (A, K, D), and minerals **(Mahammed &Al-Khshali, 2023).** wherefore Fish nutrition plays a crucial role in aquaculture as it directly affects production costs through its impact on fish growth **(Kadhim & Al-Khshali, 2020).** For humans, fish has had high economic importance since ancient times, as in some countries and regions fish constitute a high percentage of the daily food for humans **(Al-khshali, 2019).** Fish hold a prominent place in the human diet due to their significant importance in growth and body development **(Al-Azzawy &Al-Khshali, 2018).** Several studies have explored the use of available feed materials as alternatives or additives in fish nutrition. Animal by-products, including fish offal, are considered important sources for producing high-value nutritional products using modern and advanced techniques **(Al-Ash'ab & El-Shawy, 2011)** Fish feeds account for over 70% of the production cost in aquaculture projects in general. Artemia has been extensively used as live feed for fish fry **(Nasiri& Al-obaydi, 2004).** Aquaculture is one of the fastest-growing sectors worldwide, driven by the increasing demand for aquatic products, which have become preferred dietary components. This includes fish farming, aiming to reach market weight as quickly as possible **(Arslan, 2012).** To achieve this, cultivated fish species must be fed with suitable, balanced, and high-quality feeds. Feed quality, digestibility, and caloric value are among the features considered when feeding fish **(Schalekamp *et al*., 2016).** Artemia was extensively used in fish nutrition in the late seventies **(Lavens &Sorgeloos, 2000).** and due to its high nutritional value, it is widely utilized in the fishery industry. The key factor determining the nutritional efficiency of Artemia as live feed is its compatibility with the mouth opening of the larvae to be fed, its digestibility, and its possession of a long chain of unsaturated fatty acids, especially eicosapentaenoic acid and docosahexaenoic acid, which are essential for larval nutrition **(Roo *et al*. 2019).** Additionally, the protein quality in Artemia is characterized by its high digestibility coefficient compared to other animal proteins.The nutritional value of fish gut powder varies depending on the type of fish from which it is derived. Among fish species, tilapia is considered one of the best for producing fishmeal due to its high protein content, making it a good energy source for fish. It also contains various minerals such as calcium, iodine, and iron. Furthermore, it is highly palatable to fish **(Giri *et al*., 2010).**

## MATERIALS AND METHODS

The experiment was conducted at the University of Baghdad, College of Agricultural Engineering Sciences, Fish Laboratory for Postgraduate Studies. The experiment began on October 23, 2022, and continued until December 31, 2022, with a duration of 70 d. A total of 140 fish were used with an initial average weight of 35±2 grams. They were randomly and equally distributed into 14 glass tanks, comprising 7 treatments, each repeated twice, and with ten fish per replicate. The fish were subjected to a full day of fasting, after which they were fed with experimental diets (T1, T2, T3, T4, T5, T6, and T7) at a rate of 4% of their live body weight in each tank, divided into three meals per day, with a total daily feed amount of 4% of the weight. Fish were weighed every 14 days using a sensitive balance to adjust the amount of feed given based on their weights. Frozen Artemi, obtained from the local market, was dried using traditional methods. This involved spreading them in containers within the fish laboratory at a temperature of 30°C with continuous stirring to ensure proper drying. Finally, they were ground using a laboratory mill **(AL_ahtab & Al- Ubaydi., 2023).** Fresh internal organs of fish, including the digestive tract, liver, pancreas, spleen, reproductive organs, and swim bladder, were collected from fish markets. They were washed twice with water, then evenly distributed and placed in a strainer inside a pot for the purpose of removing fat at a temperature below 41°C for 5 hours. The oil and water resulting from the cooking process were removed, and the organs were dried at room temperature (27°C) until a stable weight was achieved. The dried product was ground, placed in plastic bags, and stored in the freezer until use **(Al-Zuhairi &Al-Shawi, 2020)**.

**Table (1):** Components of Experimental Diets.

| | Fish Meal Artemia | Experimental Diets | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | T1 | T2 | T3 | T4 | T5 | T6 | T7 |
| 1 | Fish Internal Organs | 0 | 6.25 | 12.5 | 0 | 6.25 | 12.5 | 25 |
| 2 | Animal Protein | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 | 0 |
| 3 | Soybean Meal | 12.5 | 6.25 | 0 | 12.5 | 6.25 | 0 | 0 |
| 4 | Bran | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 5 | Flour | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| 6 | Barley | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 7 | Smoke | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 8 | Yellow Corn | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 9 | Fish Oil | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 10 | Vitamins and Minerals | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 11 | Salt | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 12 | Total | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 13 | Fish Meal | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 14 | Artemia | %100 | %100 | %100 | %100 | %100 | %100 | %100 |

**1-** FCR: This is a measure of feed efficiency and represents the amount of feed provided to fish (in grams per fish) divided by the wet weight gain of the fish (in grams per fish). It is an indicator of how efficiently fish convert feed into body weight gain. **(Al-Zuhairi &Al-Shawi, 2020)**

$$\boldsymbol{FCR} = \frac{\text{The amount of food provided to the fish (grams per fish)}}{\text{Wet weight gain of the fish (grams per fish)}}$$

**2-** Feed Conversion Efficiency (FCE) (%): This is the inverse of FCR and is expressed as a percentage. It is calculated according to the equation referenced by. **(McCormick *et al*., 1989).**

$$\boldsymbol{FCE} = \frac{\text{Wet weight gain of the fish (grams per fish)}}{\text{The amount of food provided to the fish (grams per fish)}}$$

**3-** Amount of Protein Consumed (PI): It is calculated according to the equation mentioned by **(Gerking ,1971):**

$$\boldsymbol{PI} = Amount\ of\ Food\ Provided \times Feed\ Protein\ Percentage \frac{The\ amount\ of\ consumed\ protein}{100}$$

**4-** Protein Efficiency Ratio (PER): It is one of the indicators used to estimate weight gain per unit of protein consumed in the diet and is calculated according to the equation mentioned by **(Gerking ,1971).**

$$\boldsymbol{PER} = \frac{Total\ weight\ gain\ (grams)}{Amount\ of\ provided\ protein}$$

**5-** Protein Production Value (PPV): It represents the percentage of protein deposited in the body relative to the protein consumed in the diet and is calculated using the equation as mentioned by **(Halver &Hardy ,2002).**

$$\boldsymbol{PPV} = \frac{End\ of\ trial\ body\ protein\ (\%) - Beginning\ of\ trial\ body\ protein\ (\%)}{Provided\ food\ protein\ (grams)} \times 100$$

**6-** Net Protein Utilization (NPU): Calculated according to what**( Jasim ,2022) mentioned.**

$$\boldsymbol{NPU} = \frac{\text{Body protein at the end of the trial (\%)} - \text{Body protein at the beginning of the trial (\%)}}{\text{Food protein} \times \text{Protein Digestibility Coefficient}} \times 100$$

7- Calculating the Consumed Feed Quantity: This experiment was conducted to determine the appropriate food quantity for the fish based on the best percentage of live body weight. The fish were starved for one day, and then they were gradually fed until satiety for 2-3 h. Afterward, the remaining feed at the bottom of the tank was collected, placed in plastic containers, and dried under the sun. The weight of the remaining feed was measured, and it was subtracted from the provided feed quantity to obtain the consumed feed quantity, as described in the method **(Al-Obaidi & Jasim, 2022**).

Statistical Analysis: The data was statistically analyzed using the Statistical Analysis System **(SAS, 2012)** software, following the Complete Randomized Design (CRD) for analyzing the results. **(Yousef & Al-Khashali, 2023)** Significant differences between the means of the studied traits were tested using Duncan's Multiple Range Test at a significance level of ($p \leq 0.05$), based on the following mathematical model:

$Yij = M + Ti + \sigma ij$

Where:

- Yij = Observation value j associated with treatment effect i.

- Ti = Treatment effect on the studied trait.
- M = Overall mean of the studied trait.
- σij = Random error.

## RESULTS AND DISCUSSIONS

The results of the statistical analysis revealed significant differences in the feed consumption rates for all treatments except for the fourth treatment compared to the control group. Treatment T6 showed the highest feed consumption, followed by treatment T5, and then treatment T3, with feed quantities of 156.64, 154.39, and 146.32, respectively. This suggests that the presence of frozen and dried Artemia at a 50% ratio along with the addition of 25% of internal organ powder led to an increased acceptance of the feed by the fish, possibly due to the taste and aroma preferences of the fish for these feeds.In terms of protein consumption at the end of the experiment, treatment T6 outperformed the others, followed by treatment T3 and then T5, with protein quantities of 56.95 g, 54.21 g, and 53.09 g, respectively. It is worth noting that there were significant differences between treatment T6 and T3 across all treatments in terms of feed conversion efficiency and feed conversion ratio. Treatment T7 ranked second in terms of feed conversion efficiency, with values of 33.30, 31.37, and 30.01, respectively, for the treatments. The feed conversion ratio for the treatments was 3.19, 3.20, and 3.33, respectively. The improved digestion and absorption of the feed in the digestive tract can be attributed to the addition of Artemia to the diet, as Artemia enhances the efficiency of digestive enzymes, leading to increased fermentation in the digestive tract and improved nutrient absorption. Therefore, Artemia is considered a suitable food source for fish due to its nutritional content and ease of absorption and utilization within the fish's body. This is supported by previous research, such as the study by **(Adekunle & Joyce, 2014),** which found that adding Artemia to fish diets made them more palatable and enjoyable. Furthermore, the addition of both types of Artemia to the diets of common carp improved the feed conversion rate, as mentioned by **(Harunobu *et al*., 2001).** They noted that essential fatty acids like EPA and DHA play a significant role in muscle tissue development, leading to improved protein utilization. The energy from essential fatty acids also contributes to sparing a portion of the protein that would have otherwise been used for energy production, resulting in improved protein digestion efficiency. The addition of internal organ powder along with Artemia powder may have balanced the amino acids in the diet, which are crucial for the growth of common carp **(Fadhal & Mustafa, 2020).**

**Table (2):** Evaluation Criteria of Feeds Containing 50% Frozen and Dried Artemia and Different Ratios of Fish By-Product Powder for Common Carp (Mean ± Standard Error).

| Parameters | Treatment Food Consumption (g/fish) | Protein Consumption (g/fish) | Feed Conversion Ratio | Feed Conversion Efficiency (%) |
|---|---|---|---|---|
| **T1** | 138.04±1.51 c | 47.83±0.52 b | 4.50±0.22 b | 22.36±1.85 b |
| **T2** | 142.49±6.47 c | 44.57±2.02 b | 3.40±0.28 c | 29.61±2.41 a |
| **T3** | 146.32±6.49 c | 54.21±2.40 a | 3.20±0.37 c | 31.37±2.19 a |
| **T4** | 118.72±2.13 d | 45.71±0.82 b | 6.92±0.01 a | 14.45±0.13 c |
| **T5** | 154.39±3.25 b | 53.09±1.18 a | 3.55±0.02 c | 28.11±0.12 a |
| **T6** | 156.64±0.58 a | 56.95±0.20 a | 3.19±0.02 c | 33.30±0.27 a |
| **T7** | 144.90±5.07 b | 48.10±1.68 b | 3.33±0.07 c | 30.01±0.67 a |
| **Significance level** | * | * | * | * |

The averages that have similar letters within the same column are not statistically different from each other at the ($p \leq 0.05$) level of significance (Mean ± Standard Error).The results of the statistical analysis of the traits, including protein efficiency ratio, protein consumption, and net protein utilization (Table 3), at the end of the experiment showed that the treatments containing frozen and dried Artemia enhanced with different ratios of fish by-product powder outperformed the control treatment, except for the fourth treatment. The reason for the superiority of treatments with Artemia enhanced with internal organ powder may be attributed to the increased protein production, as Artemia is known to enhance feed utilization, resulting in higher protein production **(García & Hernandez, 2004). (Karamushko &Christionsem, 2006)** also indicated that adding Artemia to fish diets increases feed consumption and subsequently enhances protein efficiency. Furthermore, **(Chepkirui *et al*., 2011)** found that using Artemia in the feeding of African catfish (Clarias gariepinus) reduced the passage rate of nutrients in the digestive tract, leading to increased absorption and utilization of nutrients, especially protein. The quality of Artemia protein, rich in essential amino acids, also played a role. This was evident when using a 50% ratio of frozen and dried Artemia **(García *et al*., 2001).** Similarly, researcher **(Mamcarz *et al*., 2011)** observed higher protein production in fish fed Artemia compared to those fed fish meal. **(Conceição *et al*., 1997)** noted that lower moisture content in feed led to higher protein concentration and longer protein retention in the digestive tract, promoting increased net protein utilization.In addition, the use of cooked and dried fish by-product powder at air temperature enhanced the palatability of the feed and the readiness of amino acids in the feed for absorption by the simple digestive system of fish **(Wilson, 2003)**.

**Table (3):** Protein Evaluation Criteria for Common Carp Fed on Various Levels of Dried Fish By-Product Powder and 50% Frozen and Dried Artemia (Mean ± Standard Error).

| The parameters | Protein Production Quantity (g/fish) | Protein Efficiency Ratio (%) | Net Protein Utilization | Protein Consumption Quantity (g/fish) |
|---|---|---|---|---|
| **T1** | 8.21±0.85 d | 0.64±0.05 c | 0.09±0.01 d | 47.83±0.52 b |
| **T2** | 17.59±1.43 b | 0.94±0.07 a | 0.19±0.01 b | 44.57±2.02 b |
| **T3** | 22.21±1.25 a | 0.85±0.06 ab | 0.25±0.01 a | 54.21±2.40 a |
| **T4** | 8.20±0.07 d | 0.37±0.00 d | 0.09±0.00 d | 45.71±0.82 b |
| **T5** | 14.38± 0.06 c | 0.77±0.00 bc | 0.16±0.00 c | 53.09±1.18 a |
| **T6** | 20.036±0.16 ab | 0.89±0.00 ab | 0.23±0.00 a | 56.95±0.20 a |
| **T7** | 22.11±0.54 a | 0.90±0.02 ab | 0.25±0.00 a | 48.10±1.68 b |
| **Significance level** | * | * | * | * |

The means that have similar letters within the same column are not statistically different from each other at the significance level ($p \leq 0.05$). (Mean ± Standard Error)

## CONCLUSION

1- The possibility of using Artemia, both dried and frozen, supplemented with powdered fish internal organs as a source of “animal” protein in common carp diets.
2- The use of Artemia and fish internal organs powder in common carp diets works to reduce the economic cost of the diet.
3- The success of using Artemia Frozen brine shrimp in common carp diets without drying or grinding reduces the effort in feed manufacturing processes.
4- Using powdered fish internal organs in common carp feeds leads to the elimination of contaminants.
5- Adding frozen and dried brine shrimp to common carp feeds (Cyprinus) carpio by up to 50% and the internal viscera of fish by up to 25%, which led to an increase in growth standards and feed evaluation criteria, raising the apparent digestibility coefficient of the feed and improving the feed conversion rate and protein utilization, as well as increasing the consumption of the amount of feed eaten.

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