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EFFECT OF FEEDING COMMON CARP (*CYPRINUS CARPIO* (LINNAEUS, 1758)) WITH WATER FERN (*AZOLLA FILICULOIDES* (LAM.)) ON ITS FILLET QUALITY

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Purpose. *Qualitative study of fillets of common carp (Cyprinus carpio L.) fed with natural powder of water fern (Azolla filiculoides) and comparison with previous studies.*

Methodology. *The proximate composition of the samples of fish fillets was done: protein content through Kjeldahl method, lipid content was determined according to AOAC (Association of Official Analytical Chemists) official method. Sensory evaluations were done by panelists. Methods for determining water holding capacity, cooking losses and biochemical analysis were standard, accepted in the world scientific community.*

Findings. *Dissimilarities in the composition of proteins and fats were revealed. There was a significant difference in water holding capacity, cooking losses and biochemical analysis results. According to research, the powder of water fern is recommended for use in the feeding of carp, in order to improve the quality of its fillets.*

Originality. *In recent years, a significant amount of research has focused on the use of plants or their extracts in fish nutrition, due to the presence of antioxidants in them. Water fern powder is one of the cheapest dietary supplements, which can be used in aquaculture to reduced spending on cultivation, contemporaneously improving fish health. This is due to the fact that these aquatic plants are widespread in water bodies of most warm countries and contain many important antioxidants that can positively affect the quality of fish fillets.*

Practical value. *Based on the data obtained, a method for improving the quality of carp fillets has been developed. So, using water fern powder in its feeding, it is possible to improve the biochemical composition, increase taste, reduce losses during cooking, and also adjust the ability to retain water. Therefore, the proposed diet is also very useful for processing aquaculture products.*

Keywords: *water fern (Azolla filiculoides), carp (Cyprinus carpio L.), fish feeding, fish fillets quality.*

ВПЛИВ ГОДІВЛІ КОРОПА (*CYPRINUS CARPIO* (LINNAEUS, 1758)) АЗОЛОЮ ПАПОРОТЕПОДІБНОЮ (*AZOLLA FILICULOIDES* (LAM.)) НА ЯКІСТЬ ЙОГО ФІЛЕ

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Мета. *Дослідити філе коропа (Cyprinus carpio L.), в годівлі якого застосовували порошок з азоли папоротеподібної (Azolla filiculoides) та проаналізувати отримані результати на основі порівняння з попередніми дослідженнями.*

Методика. *Досліджували склад філе, зокрема визначали вміст білка за методом Кьєльдаля та вміст ліпідів, за офіційною методикою АОАС (Асоціації хіміків-аналітиків, що працюють у державних установах Сполучених Штатів Америки). Сенсорні оцінки визначали панельним методом. Методики визначення водоутримуючої здатності, втрат при варінні та біохімічних аналізів були стандартними, прийнятими у світовій науковій спільноті.*

Результати. *Виявлено відмінності у складі білків та жирів. Спостерігалась суттєва різниця щодо водоутримуючої здатності, втрат при варінні та результатів біохімічних аналізів. За результатами досліджень порошок з азоли папоротеподібної рекомендовано використовувати в годівлі коропа, з метою підвищення якості його філе.*

Наукова новизна. *Останніми роками значна кількість досліджень була зосереджена на використанні рослин чи їх екстрактів у харчуванні риб через наявність у них антиоксидантів. Порошок з азоли папоротеподібної це одна з найбільш дешевих біологічно-активних добавок до основного корму, яку доцільно використовувати в аквакультурі для зменшення витрат на вирощування, одночасно покращуючи здоров’я риб. Це пояснюється тим, що ці водні рослини широко поширені у водоймах різних країн та містять багато важливих антиоксидантів, які здатні позитивно вплинути на якість філе риби.*

Практична значущість. *На основі отриманих даних розроблено методику підвищення якості філе коропа. Так, застосовуючи порошок з азоли папоротеподібної в його годівлі можливо покращити біохімічний склад, підвищити смакові якості, зменшити втрат при готуванні, а також корегувати здатність утримувати воду. Отже, для переробки продукції аквакультури запропонований раціон також вельми корисний.*

Ключові слова: *азола папоротеподібна (Azolla filiculoides), короп (Cyprinus carpio L.), годівля риб, якість філе риб.*

ВЛИЯНИЕ КОРМЛЕНИЯ КАРПА (*CYPRINUS CARPIO* (LINNAEUS, 1758)) АЗОЛЛОЙ ПАПОРОТНИКОВИДНОЙ (*AZOLLA FILICULOIDES* (LAM.)) НА КАЧЕСТВО ЕГО ФИЛЕ

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Цель. *Исследовать филе карпа (Cyprinus carpio L.), в кормлении которого применяли порошок из азолы папоротникоподобной (Azolla filiculoides) и проанализировать полученные результаты на основе сравнения с предыдущими исследованиями.*

Методика. *Исследовали состав филе, в частности определяли содержание белка по методу Кьельдаля и содержание липидов, по официальной методике AOAC (Ассоциации химиков-аналитиков, работающих в государственных учреждениях Соединенных Штатов Америки). Сенсорные оценки определяли панельным методом. Методики определения водоудерживающей способности, потерь при варке и биохимических анализов были стандартными, принятыми в мировом научном сообществе.*

Результаты. *Выявлены различия в составе белков и жиров. Зафиксирована существенная разница по водоудерживающей способности, потерях при варке и в результатах биохимических анализов. По итогам исследований порошок из азолы папоротникоподобной рекомендуется использовать в кормлении карпа, с целью повышения качества его филе.*

Научная новизна. *В последние годы значительное количество исследований было сосредоточено на использовании растений или их экстрактов в питании рыб из-за наличия в них антиоксидантов. Порошок из азолы папоротникоподобной это одна из самых дешевых биологически активных добавок к основному корму, которую целесообразно использовать в аквакультуре для уменьшения затрат на выращивание, одновременно улучшая здоровье рыб. Это объясняется тем, что эти водные растения широко распространены в водоёмах различных стран и содержат много важных антиоксидантов, которые способны положительно повлиять на качество филе рыбы.*

Практическая значимость. *На основе полученных данных разработана методика повышения качества филе карпа. Так, применяя порошок из азолы папоротникоподобной в его кормления возможно улучшить биохимический состав, повысить вкусовые качества, уменьшить потери при приготовлении, а также корректировать способность удерживать воду. Следовательно, для переработки продукции аквакультуры предложенный рацион также весьма полезен.*

Ключевые слова: *азола папоротникоподобная (Azolla filiculoides), карп (Cyprinus carpio L.), кормление рыб, качество филе рыб.*

PROBLEM STATEMENT AND ANALYSIS OF LAST ACHIEVEMENTS AND PUBLICATIONS

Azolla is a genus of aquatic ferns and small leafed floating plants, native to the tropics, subtropics, and warm temperate regions of Africa, Asia, and America [1]. It is very sensitive to the lack of water in aquatic ecosystems such as stagnant waters, ponds, ditches, canals or paddy fields. These areas may be seasonally covered by a mat of Azolla associated with other free-floating plant species such as duckweed (*Lemna minor* L.), water lettuce (*Pistia stratiotes* L.), water caltrop (*Trapa natans* L.), water meal (*Wolffia arrhiza* Horkel ex Schleid) and mud-rooting species such as hornwort

(*Ceratophyllum demersum* L.), water purslane (*Ludwigia palustri*s L.) and knot weed (*Polygonum arenastrum*) [2].

Among published papers, tilapia species (*Oreochromis niloticus, Tilapia mossambica, Tilapia zillii*) and cyprinids (*Labeo rohita, Catla catla, labeo calbasu, Labeo fimbriatus, Ctenopharyngodon idella, Barbonymus gonionotus*) were mostly reported to utilize azolla when it is incorporated into their diets [3]. Based on research papers reviewed, azolla seems to be a good substituent of protein from expensive sources such as fish meal. The main problem in aquaculture are feeding costs especially protein sources such as soybean. In this experiment was tried to use azolla because it has a high protein content that can allow reducing feeding cost. Other problem is the acceptability of fillets of common carp fed with natural azolla, because feeding fish with natural azolla can significantly affect meat indices and improve it [4].

According to FAO [5], the long-term sustainability of aquaculture may be threatened by its present over-dependence on fish meal and fish oil. Thereby, development of viable and low-cost technologies could help to promote aquaculture in the area, as well as to increase yields and profitability. In that way, many efforts have concentrated on replacing animal protein sources such as fish meal with cheaper plant protein in fish diets [6, 7, 8, 9, 10]. Recently, the successful use of azolla as a component of fish diets was widely demonstrated in both aquaria and tanks [11, 12, 13].

Earlier studies reported improved feed utilization in Mozambique mouth-breeder [14] and increased growth in rohu [15,16], Nile tilapia [13,17], common carp, silver carp and mrigal [16] after inclusion of azolla in their feeds. Sivakumar and Solaimalai [18] have observed the beneficial effects of feeding fresh and dried azolla to *O. niloticus* in an integrated rice-fish culture system. According to Majhi et. al. [19], utilization of organic azolla by grass carp is one of the best options for the production of fish biomass from the aquatic environment.

HIGHLIGHT OF THE EARLIER UNRESOLVED PARTS OF THE GENERAL PROBLEM. AIM OF THE STUDY

According to recent studies, more than 40 % of consumed fish come from farming [20, 21]. Many studies are focused on the importance of fish as a source of proteins but also discuss its importance as a valuable source of essential long chain fatty acids, fat-soluble vitamins and pigments [22]. In addition, the benefits of fish consumption for vulnerable groups are also well recognized and due to these facts, there is a growing interest in new aquaculture fish species for many countries including Iraq. Moreover, fish skin is a valuable byproduct and is currently used as a component in animal and fish feeds.

Research on the use of aquatic plants in feeding is becoming increasingly important, since they are characterized by a high feed value. In particular, they can be used as a cheap source of essential protein in livestock and aquaculture. Of particular value to the use of aquatic plants in aquaculture is given by the fact that these plants are often natural food for aquaculture objects. Therefore, in addition to the natural susceptibility and assimilation of such dietary components by aquaculture objects, it is extremely convenient to cultivate them on various aquaculture farms [23, 24]. For example, in fish farming, they are easily introduced into the diet of herbivorous and omnivorous fish species, without additional processing, and predatory ones with additional processing. Also, such diets can be used on farms of all types of aquaculture (intensive, semi-intensive, extensive) [25].

In connection with the above, studies of the appropriateness of using in fish farming a representative of aquatic plants of the *Salviniaceae* family — water fern (*Azolla filiculoides*), ubiquitous in freshwater bodies of tropical regions of the Americas, Asia and Australia. Based on the analysis of studies already carried out on the use of this plant in agriculture, it is possible to argue that from the *Salviniaceae* family, it is the water fern that is the most promising in the green economy. At the moment, this water fern is widely used in aquaristics, because, in addition to its visual appeal, it is able to very quickly double its biomass, is unpretentious, has a high nutritional value and is able to fix nitrogen. Because of the latter, this species has become naturalized, sometimes also an invasive species, in several regions, including western Europe, southern Africa, and New Zealand, where it was used to enhance the growth rate of crops grown in water, such as rice, or by removal from lakes for use as green manure.

In aquaculture, the use of this plant as a feed additive will reduce the cost of the final product in an environmentally friendly way. It is especially important that the introduction of plants of the *Salviniaceae* family into the diet increases the quality of juvenile fish. For example, studies by Santiago et al. Indicated that juvenile Nile tilapia (*Oreochromis niloticus*) fed diets containing up to 42% *A. pinnata* were superior in linear-weight gain and survival to those fed a control (standard) diet, based on fishmeal [27]. Devi and Vishwanath compared the nutritive value and growth responses of azolla-based diets on advanced fry of the endemic medium carp (*Osteobrama belangeri)* [28]. At the moment, although there is a significant amount of research on feeding fish with water fern, however, the issues of its influence on the quality of fish fillets.

There is a general trend toward replacing the use of synthetic antioxidants in food processing by the use of natural oxidation inhibitors or by the preferential use of ingredients naturally possessing antioxidant activity. So, the major objectives of this study was to identify whether the addition of azolla extracts can delay both lipid and protein oxidation and extend the shelf life of common carp *Cyprinus carpio* L. fillets. The aim of the study provided greater insight into the potential of azolla extracts as natural and effective sources of antioxidants for fish processing.

MATERIALS AND METHODS

Experimental fish: The experiment was conducted for 60 days on 60 scaly common carp *C. carpio* transported to the laboratory of …. from Daquq/Kirkuk/Iraq. Fish weights at the beginning of the experiment varied from 59.2 to 66.4 g. Fish were placed into experimental cylindrical plastic tanks with the average initial weight of 61.45 g. Laboratory pre-acclimation and feeding with commercial pellets (their percentage of ingredients and chemical composition are shown in Table 1 and 2) were conducted for 21 days prior to feeding trials. The experiment was started on 03/05/2019.

Table 1. **Chemical composition of the different diet [29]**

Ingredients	Crude Protein, %	Crude Fat, %	Dry Matter, %	Crude Fiber, %	Energy Kcal, kg
Animal protein concentrate	40	5	92.9	2.2	2107
Yellow corn	8.9	3.6	89	2.2	3400
Soybean meal	48	1.1	89	7	2230
Barley	11	1.9	89	5.5	2640
Wheat bran	15.7	4	89	11	1300

Table 2. **Composition of experimental diet**

Ingredients	Percent
Yellow corn	15 %
Wheat bran	15 %
Animal concentrate protein	20 %
Barley	15 %
Soya bean meal 48%	35 %
Total	100%
Crud protein	28.06
Gross energy (kcal/kg feed)	2242.7

Experimental system: Fish were distributed among twelve cylindrical plastic tanks (70 L of water). Each tank was stocked with five fish. Proper continuous aeration was supplied to each tank by using Chinese's air compressors, Hailea ACO-318. A daily cleaning by siphoning method was applied to remove remained feeds and feces from the system. The experimental trial represented four treatments with three replicates; each with five fish per replicate as bellow:

T1: Feed without any addition of azolla, T2: addition of 2.5 g azolla/kg of feed, T3: addition of 5 g azolla/kg of feed, T4: addition of 7.5g azolla/kg of feed.

The replicates were randomly placed to reduce differences among treatments.

Diet formulation: The experimental diets included standard ingredients found at Sulaimani city markets, enriched with dried azolla that brought from Khurmal area of Sulaimani city. The ingredients were manually mixed to obtain dough. Then, using electrical mincer for pelleting by Kenwood Multi-processors. Drying was performed at a room temperature for four days and then the obtained mass was crushed to obtained fine particles. Feeding of fish was performed twice a day at 9:00 and 14:00 as 3% of fish body weight. Fish in every tank were weighed together bimonthly. The feeding levels were then recalculated according to new weights. The feeding trial continued for 8 weeks, then all fish were slaughtered and weighted and tests were conducted.

STUDIED CHARACTERISTICS

Physical analysis: All tests for physical analysis were conducted on fresh muscle of fish immediately after slaughtering.

Cooking loss: Twenty gram of flesh samples (with bone) were taken, accurately weighed, placed in closed aluminum boxes and cooked for 15 min in an oven pre-heated at 200ºC. After cooking, the specimens were dried with paper towel. Total cooking loss was estimated on each specimen (cooled for 30 min to 15°C) as a percentage ratio between cooked and raw weights [30].

Water Holding Capacity (WHC): The method was described by Dolatowski and Stasiak [31]. To determine the WHC, 50 g of fish muscle with bone were taken from different part of the body and then homogenized with 50 ml of distilled water for one minute by a homogenizer, then the mixture was put in a centrifuge Sigma 2-16k (speed 5000xg) for 10 min at 4ºC. The WHC was calculated as follows:

$$WHC\% = \frac{AddedWaterWeight - WaterWeightAfter\ CF}{SampleWeight} \cdot 100$$

Note: CF is centrifugation.

pH: pH of the fillet samples was measured according to Naveena and Mendiratta [32]. Ten grams were homogenized with 50 ml of distillated water and then filtered through Whatman No.1 filter paper. pH of the filtrate was measured using a digital pH meter.

Chemical and biochemical analysis:

Lipid oxidation, thiobarbituric acid (TBA) test: Twenty grams of fish fillet from different parts of fish muscle were full speed blended for 1-5 min in a blender with 50 ml of the extraction solution containing 20% trichloroacetic acid in 2M phosphoric acid. The resulting slurry was transferred quantitatively to a 100 ml volumetric flask with 40 ml of distilled water, the sample was diluted to 100 ml with distilled water and homogenized by hand shaking. A 50 ml portion was filtered through Whatman No.1 filter paper, 5 ml of the obtained filtrate was transferred to a test tube followed by adding 5 ml of thiobarbituric acid (0.005M in distilled water). The tube was then stored in a dark place for 15 hours at room temperature. The resulting color was measured using a spectrophotometer at an absorption spectrum of 530 nm [33].

TBA values as mg malonaldehyde/kg were calculated by multiplying the absorbance value of the sample by 5.2.

Sensory evaluation:

The fish fillet samples were cut to small parts and then placed in open aluminum boxes for sensory evaluation attributes (color, flavor and aroma, tenderness, juiciness and overall acceptability). The samples were cooked in an oven at 176˚C for 8.5 min until reaching the internal temperature of 70˚C, then served warm at 60˚C to eight trained panelists [34]. Muscle samples from different treatments were evaluated at each session. The samples order was random within a session. Water was served after each sample assessment. Panelists rated each sample for different attributes with a five point scale ranging between 1 and 5. The higher score values indicated a greater preference [35].

Proximate composition
Moisture content

Moisture content was determined as weight loss after samples were dried in the convection oven at 105°C until weight was stabilized [36].

Protein content

Protein content was determined according to the AOAC method [36] by using the microkejldahal method and was calculated as follows: Protein% =nitrogen ×6.25

Crude lipids content

The crude lipid of ground fish meat was determined according to Folch et al. [37].The lipid was extracted by homogenizing 3 grams of meat with 30 ml of chloroform–methanol (2:1); the lipid residue was washed twice with 15 ml of chloroform–methanol and the homogenate with washing solvent was filtered through Whatman No.1 filter paper. The filtrate was made up to 60 ml by passing additional chloroform–methanol through the filter, then washed with 12 ml of distilled water by a magnetic starrier and centrifuged at 1000×g for 20 min. The lower lipid containing layer was removed through evaporation of the upper layer solvent. The percentage of lipids was determined according to the following formula: Lipid % = (weigh of extract / weigh of sample) × 100

Ash content

Ash content was determined according to the AOAC method [36] by taking a sample of a known weight of fish flesh and placed in a muffle furnace at 550 ºC for 16 hours and then the ash percent was determined as follows:

Ash % = (W1/W2) x 100 W1 = weight of ash, and W2 = initial weight

Weight gain

Weight gain (g/fish) = mean of weight (g) at the end of the experimental period – weight (g) at the beginning of the experimental period.

Weight gain (g/fish) = w2 – w1

where: W2: fish weight (g) at the end of experimental period, W1: fish weight (g) at the beginning of the experimental period.

Statistical analysis

The general linear model (GLM) with SAS program [38], Factorial Complete Randomized Design (CRD) were used to study the effect of treatments on studied traits. The Duncans multiple range test [39] was used to determine significant differences among means.

RESULTS AND DISCUSSION

Cooking loss

Figure 1 shows that cooking loss of common carp fillets was highest (32.83%) in treatment 1 and there was no significant difference from treatment 2. Also, no significant differences ($P<0.05$) were observed between treatment 3 and 4. On the other hand, there was a significant difference ($P<0.05$) of treatment 3 and 4 with treatment 1 and 2.

The WHC of carp muscles of all studied samples were not significant ($P<0.05$), within relatively ranges between 27.05 and 32.83% (Figure 2). The samples with higher WHC values were in treatment 1 and lowest value was in treatment 4. The WHC of experimental samples in treatment 4 was significantly ($P<0.05$) higher than WHC of treatment 2 and 3.

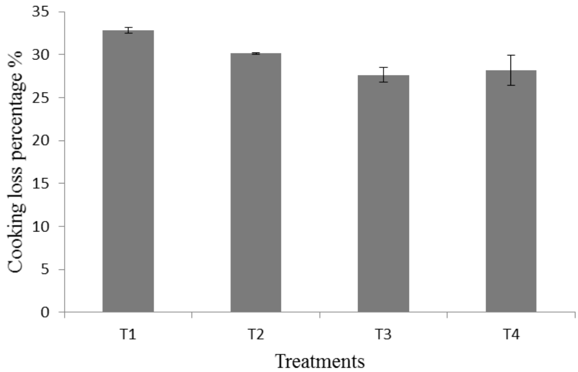

Figure 1: **Cooking loss percentage of meat of common carp fed with different levels of azolla for 60 days**

Water holding capacity

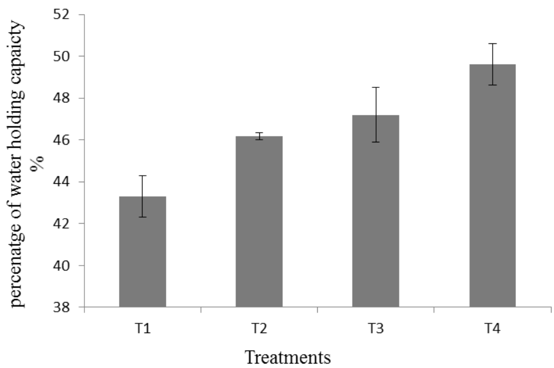

Figure 2: **Water holding capacity percentage of meat of common carp fed with different levels of azolla for 60 days**

Approximate composition

Moisture content of carp meat in treatment 1 (control) was 71.70 ± 0.30 without statistically significant differences (P > 0.05) with treatment 2 and 3, while treatment 4 significantly differed (69.18±0.74). Meat protein of fish from control group was 17.56±0.31 and statistically significantly differed (P > 0.05) from treatments 3 and 4, which were 18.55±0.15 and 19.84±0.37, respectively.

The highest fat content in carp meat was in treatment 2 (5.45±0.13), whereas the lowest content was in the control group (4.45 ± 0.46), however, a non-significant difference was observed among treatments for fat content. The highest average dry matter of meat from fish in treatment 4 was (1.35± 0.25), however the lowest value was in treatment 2 (1.07±0.02) (Table 3).

pH

In all studied samples the pH values were not significantly different (P<0.05). Higher pH values were found in the samples from the treatment 1 (6.0) in comparison to other treatments, while the lowest pH value was found in treatment 2 (4.45) (Figure 3).

Table 3. **Proximate composition of meat of common carp fed with different level of azolla for 60 days**

Treatments	Moisture %	Ash %	Fat %	Protein %
T1(control)	71.70 ± 0.30	1.09 ± 0.02	4.45 ± 0.46	17.56 ±0.31
	a	a	a	a
T2 (2.5% azolla)	70.300±0.52	1.07 ±0.02	5.45±0.13	18.34±0.44
	ab	a	a	ab
T3(5% azolla)	68.42±0.03	1.10±0.03	5.05±0.27	18.55±0.15
	a	a	a	b
T4(7.5% azolla)	69.18± 0.74	1.35± 0.25	4.70 ± 0.23	19.84±0.37
	b	a	a	b

Different letter in same column mean significant differences (P<0.05).

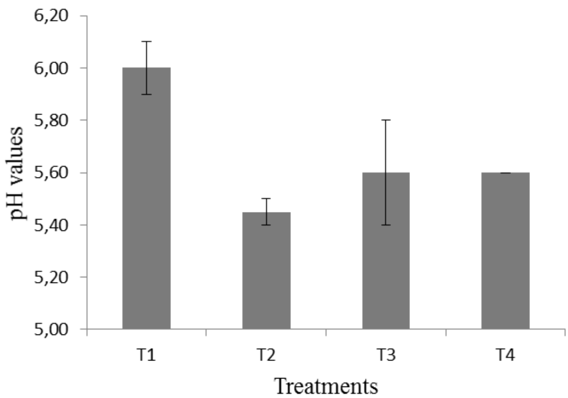

Figure 3: **pH values of meat of common carp fed with different levels of azolla for 60 days**

TBA

TBA can be considered a more suitable indicator of oxidative processes in fish meat. In this experiment, higher TBA values ($P < 0.05$) were found in fish fillets in treatment 1 (control) and no differences were found for the rest of the treatments (Figure 4).

Sensory evaluation

Sensory evaluation of the fillet samples of fish that were not fed with natural azolla compared to fish fed with natural azolla in respect to tenderness, color, flavor-aroma, juiciness and overall acceptability are shown in Table 4. There was a significant difference ($P<0.05$) between treatments 1 and 3 for fillets color, otherwise there were no significant differences ($P<0.05$) among other treatments. For juiciness, a significant difference between treatments 1 and 4 can be seen. The comparison of the control sample with samples from other treatments showed that no significant differences were noted for flavor-aroma and overall acceptance ($p<0.05$).

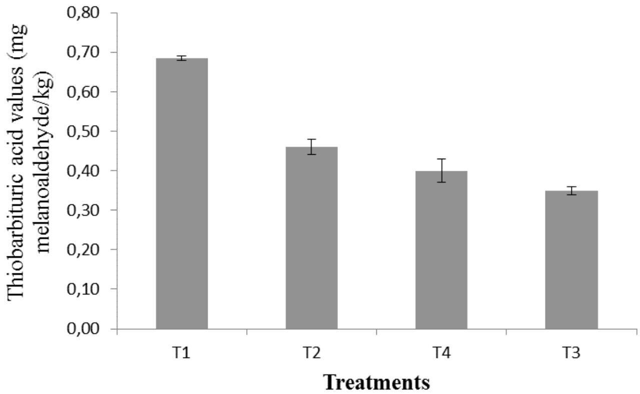

Figure 4: **TBA values of meat of common carp fed with different levels of azolla for 60 days**

Table 4. **Sensory evaluation of fillets of common carp fed with different levels of azolla for 60 days**

Treatments	Color	Flavor-aroma	Tenderness	Juiciness	Overall acceptance
T1(control)	3.85± 0.05 b	4.05 ± 0.05 a	3.65 ± 0.15 b	3.85 ±0.05 b	3.85±0.05 a
T2(2.5% azolla)	4.10±0.20 ab	4.10±0.10 a	4.00 ±0.0 ab	4.10±0.10 ab	4.10±0.10 a
T3(5% azolla)	4.45±0.05 a	4.05±0.05 a	3.90±0.10 ab	4.35±0.05 ab	3.95±0.05 a
T4(7.5% azolla)	4.05± 0.05 ab	4.00± 0.20 a	4.05 ± 0.05 b	4.35±0.20 a	3.90±0.10 a

Different letter in same column means significant differences (P<0.05).

Weight gain

There were significant differences ($p < 0.05$) in weight gain between treatment 4 and other treatments, where the highest values of weight gain were observed in treatment 4 (Figure 5).

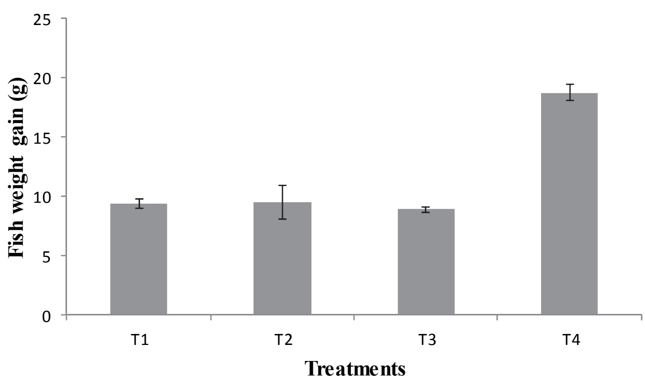

Figure 5: **Weight gain of common carp fed with different levels of azolla for 60 days.**

Azolla seems to be a good substitute of protein from expensive sources such as fishmeal. Some studies suggest positive growth even with higher azolla percentages in fish feed up to 50% [40, 41]. Some studies seem to indicate that the type and rate of fish consumption, and its growth, are related to the chemical content or nutritive value of the plants, such as the gross energy content of the diet and the dietary protein [42, 43]. Filizadeh et. al. [44] found that smaller fish had selected softer plant tissue and youngest plants, while bigger fish eat a wide variety of tough and fibrous plants.

The results of the present study did not demonstrate any significant difference among fish fed with azolla contents of 2.5%, 5% and 7.5% in their diets, in terms of ash and fat contents except protein that treatment 3 and 4 had significantly differ with treatment 1. These results were in agreement with Youssouf et. al. [45], who stated that tilapia fed with azolla (50% of feed contents) had no significant difference for fat, however, a significant difference was observed for protein percentage among treatments. In another study, Nekoubin and Sudagar [46] reported that feeding grass carp with azolla had no significant effect on fat and protein in terms of body composition. In the present study both cooking loss and water holding capacity percentage were significantly affected by feeding fish with azolla and these results corresponded to those of Hedji et. al. [47], who studied the effect of feeding pigs with azolla by 40% of feed ingredient, treatments with azolla content had significant difference for cooking loss and water holding capacity compare to control treatment that without of azolla.

In terms of sensory evaluation for common carp fed with different levels of azolla, feeds that included azolla had no significant difference of flavor-aroma and overall acceptability, while significant differences were noted among treatments for color, tenderness and juiciness. These results partially agreed with Hedji et. al. [47], who reported that feeding pork with azolla could affect texture while not affect aroma and juiciness.

WHC is the ability of meat to retain its water during processing, storage and cooking. Low WHC often results in high drip loss and poor eating quality (dryer and tougher in the cooked state). Water loss means a loss of saleable product yield. The values of pH, drip loss, cooking loss, colour are within the values reported in literature [48,49].

Conclusion

The fillet qualities and chemical composition of common carp were determined. Protein percent of body composition in treatment 1 was lowest by 17.56% and significantly differed from those of treatment 3 and 4. TBA in the control group was highest compared to the rest of treatments, while no significant difference in overall acceptance of sensory evaluation. In conclusion, it is of great interest to proceed with further investigation in that particular area especially expanding it with other local fish species from Iraqi waters with their chemical compositions and fillets quality.

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Conflict of Interest

We declare that there is no any conflict around our research.

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