Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 27(2): 709 – 721 (2023)
www.ejabf.journals.ekb.eg

The Evaluation of Bakery Waste as a Replacement for Corn Meal and Barley Flour in the Diets of the Common Carp (*Cyprinus carpio* L.) Fingerlings

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ARTICLE INFO

Article History:
Received: Jan. 17, 2023
Accepted: March 19, 2023
Online: April 29, 2023

Keywords:
Amino acids,
Digestibility,
Growth performance,
Bakery waste

ABSTRACT

The current study investigated the dietary substitution effect of corn meal (CM) and barley flour (BF) with bakery (Samoon and Khubz) waste (SKW) on growth performance, feed efficiency, digestibility and chemical composition of common carp (*Cyprinus carpio* L.). Four isonitrogenous (31.06±1.38% crude protein) and isocaloric (361.07±2.48 kcal/kg gross energy) experimental diets were formulated to replace 0% (control diet), 25%, 50% and 75% of CM and BF with SKW. The experiment was conducted in a recirculating aquaculture system. A total of 72 fish (average individual initial weight, 10.86±0.32 g) were randomly stocked and sorted in 20-liter aquariums. Each diet was randomly assigned to triplicate groups. The fish were fed twice each day to apparent satiety (*ad libitum*). The results showed that there was no significant (P>0.05) effect of SKW inclusion on the growth performance, feed efficiency and chemical composition of the fish. However, results exhibited a gradual and significant (P≤0.05) increase in the dry matter and carbohydrate digestibility of the fish with increasing dietary SKW inclusion levels. The results elucidated that SKW can replace CM and BF in the diets of common carp fingerlings by a percentage up to 75, without any adverse effects on all studied criteria.

INTRODUCTION

Food waste is considered one of the major problems around the world. According to the Food and Agricultural Organization (FAO), about one-third of the total amount of food produced for human consumption is lost or wasted every year across the entire supply chain **(Ishangulyyev *et al*., 2019)**. The quantity of waste dumped according to the Iraqi governorate for 2015 is about 2 655 156 ton, 68% of which is food waste **(Musheb, 2018)**.

There is an increased risk of food crises due to the shortage of crops, and therefore food waste must be considered as a valuable source of supply and recycled to produce energy, fertilizers and animal feed **(Wong *et al*., 2016)**.

Amongst different types of food waste, bread could be considered a major contributor to the problem, since the bakery industry is one of the most important food industries in the world. Although the utilization of bakery waste as animal feed represents an environmentally preferable route for recycling this waste, it represents economically a very low-priced option **(Koutinas, 2014)**.

Bread has been the main food staple in most Arab countries including Iraq. Almost all the meals of Iraqi people are served with bread and/or rice. In Iraq, bakeries are found in almost all neighborhoods. There are two types of Iraqi traditional bakeries. They make two types of bread, which are locally called Samoon and Khubz. Mostly, both types are made from four principal ingredients: wheat flour, water, salt and yeast.

Bakery waste consists mainly of any ingredient used in the bakery, raw or cooked, which is discarded, intended or required to be discarded, such as dough, flour, sugar and other edible ingredients including burnt or broken products **(Mahmoud, 2017)**.

Bread waste, a by-product of bakeries, is considered rich in energy and vitamins, low in fibre and free of anti-nutritional factors. It is comparable to corn in protein and amino acid profile but higher in lipids. Similarly, bakery waste is rich in non-fibrous carbohydrates (starch). The main reason for this is that wheat flour is the basic ingredient in the manufacture of most bakery products. During manufacturing, starch is already thermally processed (cooked), making it highly digestible and, therefore, of high nutritive value. Consequently, bakery waste is a kind of by-product that can be used as a high-energy feed for animal feeding **(Omole *et al*., 2011; Tiwari & Dhakal, 2021)**.

The rapid increase and instability of prices of protein and energetic concentrate feeds are significant factors in animal production to allow the competitiveness of production systems. Fish feed accounts for more than 50% of the total cost in the fish culture industry since the costs of major feed ingredients like fish meal and cereal grains (i.e. soybean, rice bran, wheat, corn, etc.) are affected by climate, weather conditions, global economic growth and fuel costs. In this context, the purpose of using low-cost alternative feeds can be an appropriate strategy for increasing the sustainability of the animal production system and bridging the gap between the requirements and availability of feeds **(França *et al*., 2012; Wong *et al*., 2016; Tiwari & Dhakal, 2021)**.

Several studies on bakery waste were done with farm livestock. Various feeding trials have shown that bakery waste is a suitable feed ingredient for sheep and lamb **(Hetherington & Krebs, 2002; França *et al*., 2012; Mahmoud, 2017)**, poultry such as broilers **(Al-Tulaihan *et al*., 2004)**, Japanese quail bird **(Edache *et al*., 2017)**, pork **(Tiwari & Dhakal, 2021)** and others. On the other hand, our review finds that very few studies have been carried out on aquatic animals, limited to **Omole *et al*. (2011)** on growing snails (*Archachatina marginata*) and **Fakunmoju (2014)** on African giant catfish (*Clarias gariepinus*) fingerlings.

Therefore, this study was designed to assess the possibility of dietary substitution of corn meal and barley flour with bakery waste and its effect on the growth performance, feed efficiency, digestibility and chemical composition of common carp fingerlings (*C. carpio*).

MATERIALS AND METHODS

Feed ingredients and diets preparation

Dietary feed ingredients (fishmeal, soybean meal, corn meal (CM), barley flour (BF), wheat bran and vitamin-mineral premix) were obtained from the local market. A blended mix of bakery (the bread which is locally called Samoon and Khubz) wastes (SKW) consisting of unsold, broken, and partially burnt bread, as well as waste dough and wasted flour from bakeries in Basrah city, south of Iraq was collected, dried and ground.

Four isonitrogenous (31.06±1.38% crude protein) and isocaloric (361.07±2.48 kcal/kg gross energy) experimental diets were prepared to assess the replacement of CM and BF with SKW. A control diet (SKW0) contained 20% of CM and 20% of BF without adding SKW. Three other diets (SKW25, SKW50 and SKW75) were prepared by replacing 25, 50 and 75% of CM and BF with SKW, respectively (Table 1).

Table 1. Ingredients and chemical composition (%) of the experimental diets substituting corn meal and barley flour for bakery waste.

	Control diet	Bakery waste substitution diets		
Ingredients (%)	SKW0	SKW25	SKW50	SKW75
Fish meal	15	15	15	15
Soybean meal	30	30	30	30
Corn meal (CM)	20	15	10	5
Barley flour (BF)	20	15	10	5
Wheat bran	14	14	14	14
Bakery waste (SKW)	0	10	20	30
Vitamin and mineral premix	1	1	1	1
Chemical composition (%)				
Moisture	5.43±0.23	5.81±0.19	5.74±0.22	5.77±0.34
Crude protein	30.97±1.84	31.14±2.01	30.98±2.1	31.17±1.17
Crude lipid	4.74±0.25	4.88±0.24	4.53±0.24	4.81±0.37
Carbohydrate	52.38±2.33	51.26±2.82	51.87±2.97	51.34±2.09
Ash	6.48±0.47	6.91±0.38	6.88±0.41	6.91±0.21
Gross energy (Kcal/100 g)[1]	362.98±2.21	361.04±2.45	359.47±2.63	360.81±3.49

1 Gross energy was calculated according to **Zhang *et al*. (2009)** using energy equivalents of 4.50, 8.50 and 3.49 kcal/g for protein, lipid and carbohydrates, respectively.

Fish, rearing conditions and experimental procedures

All the experimental procedures were carried out in the Department of Fisheries and Marine Resources, College of Agriculture, University of Basrah, Basrah, Iraq. The fingerlings of the common carp *Cyprinus carpio* used in this study were obtained from the fish culture station of the Marine Sciences Center, University of Basrah, Basrah, Iraq. Then, they were transferred to the laboratory for nutritional experiments. A total of 72 fingerlings were used, with an individual initial weight of 10.86±0.32 g; fingerlings were acclimated for two weeks to laboratory conditions during which the fish were fed by hand until apparent satiety (*ad libitum*) on a control diet (SKW0) once a day. The experiment was conducted in a recirculating aquaculture system. Fingerlings were randomly distributed among 12 experimental units (transparent plastic aquariums of 20-liter capacity), with 6 fingerlings per each one, and three units were allocated to each treatment (diet).

Fingerlings were daily fed during the 48-day trial period at a rate of 3% of their body weight divided into two meals (morning and afternoon). Samples were weighed every two weeks to adjust the amount of feed provided and monitor growth performance, represented by weight gain (WG), relative growth rate (RGR) and specific growth rate (SGR), as well as measuring feeding efficiency, represented by feed conversion ratio (FCR), protein efficiency ratio (PER), and protein productive value (PPV) according to the following equations:

$WG\ g = FW\ g - IW\ g$

$RGR\% = (WG\ g / IW\ g) \times 100$

$SGR\ \%/day = ((\ln FW\ g - \ln IW\ g) \times 100) / t$

$FCR = FC\ g / WG\ g$

$PER = WG\ g / PC\ g$

$PPV\% = (PG\ g / PC\ g) \times 100$

Where, FW is the final body weight; IW is the initial body weight; t is the experimental period in days; FC is feed consumed; PC is protein consumed, and PG is protein gain.

The water quality parameters represented by temperature, dissolved oxygen, salinity and pH were weekly monitored. During the trial period, their values were 25.48±0.52 °C, 7.74±0.12 mg/L, 1.44±0.05 PSU and 7.38±0.06, respectively.

The chemical composition of experimental diets and fish

The chemical composition of raw materials and fish were measured using standard methods mentioned in the Association of Official Analytical Chemists **(AOAC, 2005)**. Moisture was determined by oven-drying at 105°C for 24 h; crude protein content (N×6.25) was determined according to the Kjeldahl method after acid digestion; crude lipid was determined by ether-extraction using a Soxhlet extraction apparatus, and ash was determined by a muffle furnace at 550°C for 24 h.

Amino acid analysis of ingredients

The amino acid profiles of CM, BF and SKW were determined at the laboratories of the directorate of chemistry and materials research, Ministry of Science and Technology, Baghdad, Iraq, using a high-performance liquid chromatography (HPLC) system (Shimadzu, Japan) after acid hydrolysis of samples **(Dziągwa-Becker *et al*., 2015)**, except for tryptophan. It was determined spectrophotometrically after alkali hydrolysis **(AOAC, 2005)**.

Apparent digestibility and faecal collection

A digestion trial was conducted after the end of the growth trial, using the same fish and at the same rearing system without recycling water during faecal collection. Apparent digestibility coefficients (ADC) were measured using the indirect method, and chromic oxide as an inert indicator was included in each experimental diet at a concentration of 1% dry weight. The fish were hand fed the diets to visual satiety once a day in the morning for three weeks. Two hours after feeding, the rearing aquariums were cleaned by siphoning. Uneaten feed and faecal material were removed. Then, faeces were removed directly from the aquaria every 20 min by siphoning as well, filtered with filter paper, and dried in the oven (60 °C for 48 h). The concentrations of chromic oxide in diets and faeces were determined by spectrophotometry following nitric-perchloric acid digestion according to the procedure described by **Furukawa and Tsukahara (1966)**. The apparent digestibility coefficient of dry matter (ADC_{dm}) and nutrients (ADC_n) in diets were determined according to **Talbot (1985)** as follows:

$ADC_{dm}\% = 100 - (100 \times (\%\text{ chromic oxide in feed } / \text{ \% chromic oxide in faeces}))$

$ADC_{n}\% = 100 - (100 \times (\%\text{ chromic oxide in feed } / \text{ \% chromic oxide in faeces}) \times (\%\text{ nutrient in faeces } / \text{ \% nutrient in feed}))$

Statistical analysis

Results are presented as mean±SD; all data were exposed to one-way analysis of variance ANOVA; the treatment means were further compared with Duncan's new multiple range test to determine the significant differences ($P \leq 0.05$), and all statistical analyses were performed using the IBM SPSS software version 22.0.

RESULTS

The results of the chemical composition of SKW, CM and BF are shown in Table (2). The results revealed a great convergence between SKW and CM. There were no significant differences ($P > 0.05$) between them for all components except for the percentage of moisture, which was less significant ($P \leq 0.05$) in SKW. BF showed that it contains significantly less protein and total energy compared to SKW and CM, which in turn was reflected in the protein: energy ratio (P: E ratio), which averaged 37.2 mg of protein per kilocalorie compared to their average, which was approximately 41 mg of protein per kilocalorie in CM and SKW.

Table 2. The chemical composition (%) of bakery wastes (SKW), corn meal (CM) and barley flour (BF)

Nutrient (%)	SKW	CM	BF
Moisture	5.23±0.13^{b}	6.85±0.11^{a}	6.69±0.15^{a}
Crude protein	14.21±0.28^{a}	14.17±0.33^{a}	12.71±0.29^{b}
Crude lipid	2.20±0.09^{ab}	2.48±0.12^{a}	2.01±0.1^{b}
Carbohydrate	75.48±0.34^{ab}	74.54±0.47^{b}	76.36±0.42^{a}
Ash	2.89±0.09^{a}	1.97±0.09^{b}	2.24±0.11^{b}
Gross energy (kcal/100 g)	346.78±0.87^{a}	345.69±0.85^{a}	341.52±0.66^{b}
P:E ratio (mg protein/kcal)	40.98±0.71^{a}	40.99±0.84^{a}	37.20±0.78^{b}

Values in each row with the different superscript letters indicate a significant difference ($P \leq 0.05$).

Table (3) shows the composition of the essential amino acids in SKW, CM and BF. All essential amino acids were recorded in SKW. The total percentage of essential amino acids in SKW was 35.38%, and it was very similar to its percentage in CM (36.95%), but it was reduced to 31.67% in BF. The SKW recorded the largest percentages of isoleucine, phenylalanine and threonine while recording the lowest percentage of lysine. CM was higher in its content of arginine, histidine, leucine, lysine, methionine and valine, whereas it was lower for isoleucine and tryptophan. BF outperformed in tryptophan only though underperformed in its content of histidine, leucine, methionine, threonine and valine.

Growth performance, nutritional conversion and protein utilization of *C. carpio* fingerlings fed experimental diets after 48 days of the growth experiment are shown in Table (4). The results indicate that the process of replacing CM and BF with SKW did not affect growth performance. The values of WG, RGR and SGR insignificantly ($P>0.05$) converged. The highest value of WG (5.42 g) was recorded in fish fed SKW50, while the lowest value (5.13 g) was recorded in fish fed SKW25.

Fish fed SKW0 displayed the highest values for the RGR and SGR (49.39 % and 0.835 % daily), whereas fish fed SKW25 displayed the lowest values (47.37 % and 0.807 % daily).

Table 3. The essential amino acids profile (% crude protein) of bakery wastes (SKW), corn meal (CM) and barley flour (BF).

Amino acid	SKW	CM	BF
Arginine	2.29	3.17	2.31
Histidine	1.98	2.65	1.84
Isoleucine	3.93	3.08	3.49
Leucine	6.96	7.17	4.94
Lysine	2.48	4.56	3.37
Methionine	2.51	2.99	1.77
Phenylalanine	5.85	4.19	4.98
Threonine	4.07	3.69	3.35
Tryptophan	1.21	1.02	1.86
Valine	4.1	4.43	3.96
Total EAA	35.38	36.95	31.67
Total non EAA	64.62	63.05	68.33

Likewise, nutritional conversion and protein utilization did not differ significantly among all diets. FCR slightly insignificantly improved with the increase in the rate of SKW inclusion in the diets, which ranged from 3.08 in SKW0 to 2.93 in SKW75. The PER and PPV exhibited almost similar results in turn. The diets did not show any significant difference between them. The highest values were observed (1.10 and 16.74%) in SKW50 and the lowest values (1.05 and 16.14%) in SKW0 for the PER and PPV, respectively. No mortalities were observed in experimental fish during the growth experimental period.

Table 4. The growth performance and feed efficiency of common carp fed the experimental diets substituting corn meal (CM) and barley flour (BF) for bakery waste (SKW)

Parameter	SKW0	SKW25	SKW50	SKW75
IW (g)	10.58±0.34	10.81±0.24	11.09±0.32	10.96±0.28
FW (g)	15.82±1.09	15.93±0.91	16.51±0.98	16.34±1.07
WG (g)	5.24±0.76[a]	5.13±0.68[a]	5.42±0.66[a]	5.38±0.8[a]
RGR (%)	49.39±5.68[a]	47.37±5.35[a]	48.82±4.5[a]	49.00±6.13[a]
SGR (%/day)	0.835±0.079[a]	0.807±0.076[a]	0.828±0.063[a]	0.830±0.086[a]
FCR	3.08±0.21[a]	2.99±0.19[a]	2.95±0.22[a]	2.93±0.23[a]
PER	1.05±0.08[a]	1.08±0.07[a]	1.10±0.08[a]	1.09±0.09[a]
PPV (%)	16.14±1.45[a]	16.18±1[a]	16.74±0.96[a]	16.51±1.61[a]

Values in each row with the different superscript letters indicate a significant difference ($P \leq 0.05$).

Table (5) displays the dry matter and nutrient ADCs (protein, lipid, and carbohydrate) of common carp fingerlings fed the experimental diets that substitute CM and BF for SKW. The ADC_{dm} of carp fingerlings fed an SKW75 diet was significantly ($P \leq 0.05$) higher than that of fish fed SKW0 diet. Moreover, the ADC_{dm} of carp fingerlings fed SKW75 and SKW50 diets were significantly higher than those of fish fed SKW0 diet. Otherwise, there was no significant effect ($P > 0.05$) noticed of SKW on the ADCs of crude protein and crude lipid among dietary treatments.

Table 5. The apparent digestibility coefficients for dry matter (ADC_{dm}) and nutrients (ADC_n) in common carp fed the experimental diets substituted corn meal (CM) and barley flour (BF) for bakery waste (SKW)

ADC (%)	SKW0	SKW25	SKW50	SKW75
Dry matter (ADC_{dm})	69.71 ± 1.53^{b}	72.98 ± 1.88^{ab}	73.59 ± 1.55^{ab}	74.71 ± 1.61^{a}
Crude protein (ADC_n)	78.13 ± 1.65^{a}	77.92 ± 2.07^{a}	78.26 ± 1.93^{a}	78.22 ± 1.69^{a}
Crude lipid (ADC_n)	77.24 ± 2.05^{a}	76.81 ± 1.98^{a}	77.09 ± 1.86^{a}	77.24 ± 2.02^{a}
Carbohydrate (ADC_n)	62.97 ± 1.54^{c}	64.18 ± 1.71^{bc}	65.58 ± 1.89^{ab}	67.82 ± 1.73^{a}

Values in each row with the different superscript letters indicate a significant difference ($P \leq 0.05$).

Table (6) shows the chemical composition of the whole body of common carp fingerlings at the beginning and end of the experiment. The percentage of dry matter (which ranged from 24.84% to 25.91%) and the percentage of ash (which ranged from 2.64% to 3.01%) in the fish body were maintained close to their values before the start of the experiment (23.72% and 3.06%, respectively). Furthermore, it also did not indicate that there were significant differences ($P > 0.05$) among the treatments at the end of the experiment. The percentage of body protein in the fish increased significantly ($P < 0.05$) across all dietary treatments from the start of the experiment to the end. Alternatively, the replacement of CM and BF with SKW did not cause any significant ($P > 0.05$) effect on fish body protein among dietary treatments. The percentage of crude lipids increased slightly with the increase of dietary SKW. Crude lipid in fish fed SKW0 diet indicated the lowest significant ($P < 0.05$) percentage, compared to the rest of the other dietary treatments and its percentage before the beginning of the experiment.

Table 6. The chemical composition of the whole body of common carp fed the experimental diets, substituting corn meal CM and barley flour BF for bakery waste SKW at the start and end of the experiment

Nutrient (%)	Initial	SKW0	SKW25	SKW50	SKW75
Dry matter	23.72 ± 1.49^{a}	24.84 ± 1.67^{a}	24.93 ± 1.44^{a}	25.09 ± 1.32^{a}	25.91 ± 1.04^{a}
Crude protein	14.04 ± 0.52^{b}	16.59 ± 0.54^{a}	16.02 ± 0.66^{a}	16.49 ± 0.64^{a}	15.98 ± 0.61^{a}
Crude lipid	6.62 ± 0.52^{a}	5.65 ± 0.51^{b}	5.90 ± 0.46^{a}	5.96 ± 0.61^{a}	6.17 ± 0.56^{a}
Ash	3.06 ± 0.4^{a}	2.69 ± 0.43^{a}	3.01 ± 0.51^{a}	2.64 ± 0.45^{a}	2.56 ± 0.43^{a}

Values in each row with the different superscript letters indicate a significant difference ($P \leq 0.05$).

DISCUSSION

The chemical composition of the bakery waste (SKW) exhibited that their moisture content was less significant than that of corn meal (CM) and barley flour (BF). This could be due to processing methods used during making bread, which include high heat and finely ground and sieved raw material (wheat), which makes it easy to dry. The crude protein content of SKW was nearly the same as that of CM but less than BF. The highest value of crude lipid content was noticed in CM, followed by SKW and BF, which decreased significantly compared to the CM, and this could be the reason for the lower energy content and P: E ratio of BF compared to SKW and CM. Generally, the SKW content of nutrients and energy is almost similar to CM and better than BF. This could be explained by the high-quality wheat flour used for making bread in most bakeries in Iraq. Furthermore, as mentioned by **França *et al*. (2012)**, there is a wide difference in the previous studies about the chemical composition of bakery waste, which makes it difficult to compare, basically due to the quality of ingredients used and their origin, as well as storing and processing methods.

The large convergence in the chemical composition between SKW and CM; besides, the relatively low proportion of dietary BF replaced by SKW, as well as the low content of protein and lipid of these ingredients caused the chemical composition of the experimental diets to reveal no significant differences in crude protein and energy content.

The content of the nutritionally essential amino acids in the ingredient's protein is considered the primary determinant of its quality **(Mohanty *et al*., 2014)**. The results indicate that the used dietary ingredients (KSW, CM, BF) contain all ten essential amino acids (Arginine, Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Tryptophan and Valine) assessed in the study of **Takeuchi *et al*. (2002)** in varying amounts. It is clear from the results that KSW is not rich in lysine, compared to the CM and BF. However, the methionine value of KSW was much higher than its value in BF and close to CM.

The experiment revealed that the replacement of CM and BF by SKW up to 75% in common carp fingerlings' diets did not affect growth performance (WG, RGR and SGR) and feed efficiency (FCE, PER and PPV). Indeed, fish fed the SKW diet showed slightly improved FCR among treatments. Thus, current results suggest that CM and BF could be replaced with cheaper SKW up to 75% without adverse effects on the growth performance and feed efficiency of common carp fingerlings. These results may be a reflection of the nutritive values of SKW, which are almost similar to CM and even better than BF. These results are well matched with those of **Fakunmoju (2014)** who reported that, weight gain improved upon increasing the replacement of 30% dietary maize with bread waste in the diets of the African giant catfish (*C. gariepinus*) fingerlings up to 100%. Likewise, these results are compatible with those of **Omole *et al*. (2011)** when bread waste substituted up to 100% of 22% of dietary maize in a growing snail (*A.*

marginata) diet. Furthermore, similar results were reported for some terrestrial animals. **Hetherington and Krebs (2002)** carried out a trial to investigate the effect of incorporated bakery waste (0, 25, and 50%) on sheep diets; results showed that there was no significant difference in live weight gain between the treatments, and feed conversion ratios tended to be higher in the 50% bakery waste group.

Mahmoud (2017) found that bakery by-products can replace corn grains and wheat bran in concentrate feed mixtures by up to 60% in growing lamb rations with an increasing growth rate. **Al-Tulaihan *et al*. (2004)** evaluated the use of dried bakery waste in the diets of broilers. The previous authors concluded that, the replacement of about 50% of the dietary corn inclusion did not negatively affect the performance. Similarly, bakery waste could completely replace maize in the diets of Japanese quail chicks **(Edache *et al*., 2017)** and pork **(Tiwari & Dhakal, 2021)** without any adverse effect on growth performance.

The study of apparent digestibility coefficient values is considered an important aspect in assessing the potential feed components for the formation of nutritionally sufficient diets **(Irvin & Tabrett, 2005; Jannathulla *et al*., 2018)**. Digestibility describes the portion of the nutrients that is not excreted in the faeces, and it is considered one of the most important features in estimating the efficiency of feed ingredients **(Asad *et al*., 2014)**. The current study's results showed that replacing dietary CM and BF with SKW did not affect the ADCs of protein and lipid. Meanwhile, in terms of dry matter digestibility, they showed a slightly gradual improvement (69.71–74.71%) as dietary SKW incorporation increased. These results are consistent with the findings of **Champe and Church (1980)** with respect to sheep. Correspondingly, this might be due to the corresponding increase in carbohydrate digestibility, which improved (62.97–67.82%) significantly in SKW50 and SKW75 diets. The improvement in carbohydrate digestion may be due to the higher percentage of highly digestible gelatinized starch in SKW as a result of their being thermally processed (cooked) during the manufacture of bread **(Olomu, 1995 cited in Mahmoud, 2017, p. 1215; Tiwari & Dhakal, 2021)**. Faridi and Rubenthale (1984) mentioned that the Baladi bread (made in a very similar way to Iraqi bread) is usually baked at high temperatures (450-500 °C) and also has a high dough water absorption (70–75%). Gelatinization occurs in the presence of water and heat and effectively breaks down the starch granule, exposing the bound amylase fraction and increasing the surface area, which renders the starch more susceptible to enzymatic attack **(Stone, 2003; Romano & Kumar, 2018)**. When compared to the low digestibility of native starches, it was concluded that gelatinization promoted a positive effect on starch digestibility **(Bergot & Breque, 1983; Hernandez *et al*., 1994)**.

In the current study, moisture, crude protein and ash composition of the whole body of common carp fingerlings were not affected by the dietary substitution of dietary CM and BF with SKW. Only the crude lipid in SKW0 decreased significantly. This is consistent with the results of the chemical composition of diets, growth performance, feeding efficiency and digestibility in the current study. The recorded values of chemical composition are close to the values previously recorded in the study of **Al-Humairi *et al*. (2020)**.

CONCLUSION

In the current study, the results elucidated that bakery (Samoon and Khubz) waste (SKW) can replace corn meal (CM) and barley flour (BF) in the diets of common carp (*C. carpio*) fingerlings by a percentage up to 75, without any adverse effects on growth performance, feed efficiency, carcass chemical composition and digestibility coefficient.

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