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Analysis of Nutrient Content in Common Carp (*Cyprinus carpio*) and Crucian carp (*Carassius carassius*) Fish Offal

Deribew Hailu* and Nura Tuma

Oromia Agricultural Research Institute, Batu fish and Other Aquatic Research Center, Ethiopia.

Abstract

Fish meal preparation and utilization began during the early 1800s in northern Europe and North America based primarily on surplus herring catches. The experiment was conducted at Batu Fish and Other Aquatic Life Research Center from July 2020 to June 2021 using two commercially important fish species, Common carp (*Cyprinus carpio*) and *Crucian carp* (*Carassius carrassius*) to analyze the nutrient contents. Offal collected from processing shade of Batu Fishermen cooperatives. Discarded parts of fish like internal viscera, which include: the digestive tract, liver, pancreas, spleen, gonads and air sac that are not sold because they are not suitable for human consumption were used to prepare fish meal. Offal from both species was divided into two groups. One group was dried without cooking the offal. The remaining group was cooked, pressed, dried, and ground into fine powder. The cooked common carp fish meal had significantly ($p<0.05$) low moisture content (6.6558 ± 0.1133) as compared to uncooked one (7.5028 ± 0.3291). Cooking has significantly lowered ($p<0.05$) potassium, Manganese and Iron content as compared to uncooked common carp fish meal. However, cooking has significantly ($p<0.05$) increased Zinc content as compared to uncooked one in common carp. Regarding Crucian carp, cooked crucian carp fish meal had significantly ($p<0.05$) low moisture content (5.973±0.4813) as compared to uncooked one (7.0326±0.8826). Cooking has significantly increased ($p<0.05$) Manganese and Iron content as compared to uncooked Crucian Carp fish meal. However, cooking has significantly ($p<0.05$) lowered Zinc content as compared to uncooked one. The cooked common carp fish meal had significantly ($p<0.05$) high moisture content, crude protein, Potassium, Manganese and Zinc as compared to cooked Crucian carp. However, cooked common carp fish meal had significantly ($p>0.05$) low Sodium and Iron as compared to cooked Crucian carp. The uncooked common carp fish meal had significantly ($p<0.05$) high Potassium, Manganese and Iron as compared to uncooked Crucian carp. However, uncooked common carp fish meal had significantly ($p>0.05$) low Crude ash as compared to cooked Crucian carp. It was concluded that cooked offal of common carp has better protein content, hence it preferred to be used as an animal feed over Crucian carp.

Keywords: Common carp; Crucian carp; Fish offal; Nutrient content

Introduction

Fishmeal is a generic term produced from a nutrient-rich feed ingredient commonly used for poultry and other domestic animals diet for many decades. It can be made from almost any type of seafood but is generally manufactured from wild-caught, small marine fish that contain a high percentage of bones and oil which are not suitable for direct human consumption. A small percentage of fish meal is rendered from the by-catch of other fisheries, and by-products or trimmings created during processing of various seafood products destined for direct human consumption. Fish meal preparation and utilization began during the early 1800s in northern Europe and North America based primarily on surplus herring catches. The early industry was geared towards the production of fish meal for high nitrogen and phosphorus fertilizer. Fish meal has become a fertilizer and the high protein content makes it very suitable as an animal feedstuff [1]. It has high levels of essential amino acids such as methionine and lysine, and it also has a good balance of unsaturated fatty acids, certain minerals (available phosphorus), and vitamins (A, D, and B-complex).Fresh fish offal processed under local condition using locally available materials and dried on rack are appropriate and good in feed quality for livestock.

The composition of fishmeal varies according to the species of fish, method of processing, and whether fillets have been removed for separate markets. Anchovies and menhaden are processed whole, with resulting meals containing 64 and 61% protein, respectively. Marine based ingredients, especially fish meals, are highly sought after as the protein source of choice for many formulated diets. That is because fishmeal provide feeds with high contents of essential amino and fatty acids, and low content in carbohydrates; thus being usually well digested and mainly used by feeds industry as a rich source of protein. Fish meal (FM) carries large quantities of energy per unit weight and is a source of high-quality protein and highly digestible essential amino and fatty acids. The nutritive value of fish meal varies depending on sources of input, place of harvest and addition of salt for preservation. In Ethiopia, the chemical composition of tilapia and Catfish was studied by different scholars, but there is no any information about common carp *(Cyprinus carpio)* and *crucian carp (Carassius carassius)* fish offal chemical composition. Though there is limitation of information on chemical composition of these two species of fish, the production and left over of common carp and crucian carp increases from time to time in different water bodies of Ethiopia including Lake Denbel/Ziway. So, conducting a research on chemical profile of common carp and crucian carp is unquestionable to utilize as fish feed for future times. Understanding the chemical composition of various fish meals used in animal or aqua feed are essential for formulating artificial diets. The aim of this study was to determine the chemical composition of fish

***Corresponding author:** Derribew Hailu, Oromia Agricultural Research Institute, Batu Fish and Other Aquatic Life Research Center, Batu Ethiopia, E-mail: hailuderribew@yahoo.com

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meal prepared by cooking and un-cooking from common carp and crucian carp fish species.

Materials and Methods

Sample preparation

The raw material used for production of fish meal was Common carp and Crucian carp offal was collected from Ziway-Batu fishermen cooperative processing shade. Parts of discarded fish consist of internal viscera, which include: the digestive tract, liver, pancreas, spleen, gonads and air sac that are not sold because they are not suitable for human consumption. Offal from both species was categorized into two groups. One group was dried without cooking offals [2]. The remaining group was cooked according the procedure. *It involves* cooking, pressing, drying, and grinding of fish or fish waste into a solid.

Cooking: The purpose of the heating process is to liberate the oil from the fat depots of the fish, and to condition the material for the subsequent treatment. The fresh fish offal was cooked-until the flesh opaque and separates to about 95 ºC -100 ºC for about 30 minutes. In this step, oil from fat deposits and moisture content librated and un-wanted materials was sterilized.

The cooked offal was left to settle in the barrel over night. That is from 6 pm to 8 am (morning) to separate the oil, water and solid components.

Pressing: The purpose of the press is to squeeze out as much liquid as possible from the solid phase. This is important not only to improve the oil yield and the quality of the meal, but also to reduce the moisture content of the press cake as far as possible, thereby reducing the fuel consumption of the dryers and increasing their capacity. The pressed by-products were spread on the laminated tin on rack for drying in the sun.

Drying: The purpose of the drying process is to convert the wet and unstable mixture of press cake, decanter sludge and concentration into a dry and stable fish meal [3]. In practice, this means drying to a moisture content below 12%, which generally may be considered low enough to check microbial activity. This drying is done by heating the material to a temperature where the rate of evaporation of the water is considered satisfactory.

Grinding, packaging and Storing: The dried meal both from (cooked and uncooked) are ground using Laboratory miller to appropriate size. The ground powder was packaged using polyethylene bags stored in dessicator until anlayzed.

Estimation of total carbohydrate: The percentage of carbohydrate was calculated using the formula: 100-(percentage of ash + percentage of moisture + percentage of fat + percentage of protein).

Estimation of nutritive value /Energy: Nutritive value of the sample will be determined by multiplying the values obtained for protein, fat and carbohydrate by 4.00, 9.00 and 4.00, respectively and adding up the values.

Determination of proximate composition

Moisture content: Moisture percentage was determined by weighing every petri dish and the wet sample. Consequently sample was dried in an oven at 105°C for 3 hours [4]. Then petridish along with dried sample was placed in desiccators for 30 minutes. Eventually, the weight of petridish and dried sample was weight. The moisture percentage was calculated using the following formula:

Moisture % = 100 * ((wet sample weight – dry sample weight)/wet sample weight)

Crude protein: Protein a percentage was is determined through the Kjeldahl method. VELP DK Series Digestions Unit and a VELP UDK 159 Automatic Digestion were used subsequently. Every Kjeldahl flask was prepared to add 2 catalysts for digestion. This included 1 g of the dried sample, 0.2 g $CuSO_4$ and 7 g of K_2SO_4. For the actual digestion, also 12 ml of H_2SO_4 was added. Digestion was completed at 420°C for 1 hour. Eventually the sample was cooled down to 50°C. The sulfuric acid converts all nitrogen in organic form into inorganic form that is stable and suitable for analysis:

$$H_2SO_4 + \text{Organic N} \rightarrow (NH_4)_2SO_4 + CO_2 + H_2O + \text{other compounds}$$

For the distillation, distilled water was added. The nitrogen was separated from the digested mixture by steam distilling with the UDK 159 in order to extract ammonia from the alkaline solution [5]. Sodium hydroxide (40 %) was added to raise the pH and convert solid NH_4^+ into gaseous NH_3. The distilled nitrogen was then trapped by adding boric acid.

$$(NH_4)_2SO_4 + 2NaOH \rightarrow 2NH_3 + Na_2SO_4 + 2H_2O$$

$$NH_3 + H_3BO_3 \rightarrow NH_4\ H_2BO_3 + H_3BO_3$$

For the final colorimetric titration, hydrochloric acid was added in order to react with the ammonia and the indicators. The volume of titrant that was needed to reach the end point, allows to automatically calculating the amount of nitrogen, expressed as % N.

Crude fat: Crude fat was determined using Soxhlet fat extractor, consisting of a rounded-bottom flask, an extraction chamber and a condenser. For 200 ml extraction chambers, 50 ml of diethyl ether was used as extraction solvent. Approximately 2 grams of dried sample in a filter was placed into the extraction chamber to conduct the fat extraction [6]. The rounded-bottom flask was weighed before each sample in case some fat remained from the previous sample. The sample was subjected to 3 hours of extraction. Afterwards the rounded-bottom flask containing the fat was placed in the oven to eliminate any remaining petroleum diethyl ether and were weighed again. The fat percentage will calculated using the following formula:

Fat % = 100 * ((weight rounded-bottom flask & fat – weight rounded-bottom flask)/dry sample weight).

Crude ash: The sample was ashed in order to be able to analyse the mineral content afterwards. Two grams of the dried samples was be placed in crucible cups that were weighed beforehand. Prior to placing the samples in the oven, they will be charred on hot plates for 30 minutes to prevent excess smoke production. The ashing itself will be done by placing the crucible cups in a 550°C oven for 8 hours. The following formula was used to calculate the ash percentage:

Ash % = 100 * (weight ash/weight dry sample)

Data analysis: Data of proximate composition (moisture, protein, fat and ash) of cooked and uncooked common carp and crucian carp was analyzed using t-test [7]. Means were separated where significant different were detected.

Results and Discussion

The proximate composition and Minerals content of Common Carp both cooked and uncooked is presented in (Table 1).

Cooking has statistically significant effect on the moisture content,

Table 1: The proximate composition and Minerals contents of Cooked and uncooked Common carp.

Parameters	Cooked	Uncooked	P-value
Moisture Content	6.6558±0.1133[b]	7.5028±0.3291[a]	0.039
Crude Protein	64.2305±1.9246[a]	63.4113±2.361[a]	0.862
Crude Fat	6.7158±0.6244[a]	9.1158±0.5061[a]	0.125
Crude Ash	25.9372±0.161[a]	21.4509±0.1331[b]	0.00
Gross energy (Kcal/ 100g)	317.3642	335.687	
Sodium	2518.21±10.25[a]	2472.34±4.077[a]	0.074
Potassium	8579.6566±44.358[b]	8965.2666±35.12[a]	0.001
Manganese	54.313±0.3894[b]	83.11±0.9063[a]	0.000
Iron	665.892±19.1836[b]	1707.72±40.47[a]	0.003
Zinc	531.7566±1.798[a]	369.7433±1.461[b]	0.000
Magnesium	2570.35±97.96[a]	2286.87±50.076[a]	0.143

Table 2: The proximate composition and Minerals contents of cooked and uncooked Crucian carp.

Parameters	Cooked	Uncooked	P-value
Moisture Content	5.973±0.4813[b]	7.0326±0.8826[a]	0.009
Crude Protein	58.8839±0.6717[a]	57.4321±6.352[a]	0.826
Crude Fat	7.3563±0.719[a]	10.0347±0.715[a]	0.150
Crude Ash	25.92±0.5111[a]	26.2575±0.7642[a]	0.168
Gross energy (Kcal/ 100g)	301.7423	320.0407	
Sodium	2705.1967±8.1913[a]	2561.6±28.17[b]	0.05
Potassium	8071.77±60.056[a]	8466.5±157.13[a]	0.168
Manganese	42.56±1.872[a]	53.3067±0.425[b]	0.04
Iron	1992.423±21.9[a]	676.2466±19.017[b]	0.001
Zinc	405.8433±4.644[b]	550.92±10.216[a]	0.01
Magnesium	2316.86±46.616[b]	2797.22±76.42[a]	0.044

crude ash, Potassium, Manganese, Iron and Zinc of fish meal of common carp. The result obtained from the present study shows that cooked fish meal has lower final moisture contents as compared to uncooked ones. Cooking or heating has no statistically significant ($p>0.05$) effects on protein contents, fat and Sodium and Magnesium of fish meal. The cooked common carp fish meal had significantly ($p<0.05$) low moisture content (6.6558 ± 0.1133) as compared to uncooked one (7.5028 ± 0.3291). Cooking has significantly lowered ($p<0.05$) potassium, Manganese and Iron content as compared to uncooked common carp fish meal [8]. However, cooking has significantly ($p<0.05$) increased Zinc content as compared to uncooked one. In the present study, the moisture content is far below 15 %.fish meal could have shelf life over one year for offal dried to below 15% moisture content. Cooking increases the release of liquor, hence, the moisture content of cooked fish meal is lower that of uncooked fish meal. This corroborates the reason why cooked offal has lower moisture content as compared to sun dried offal. Cooking has no effect on the concentration of Grouper (*Epinephelus morio*), red snapper (*LuGanus campechanus*), Florida pompano (*Trachinotus carolinus*) and Spanish mackerel (*Scomberomorus macuhtus*) of microelement, Zinc, Copper, Iron and Manganese.

Crude ash, crude protein and crude fat contents of cooked fish increased due to rise in dry matter contents. Accordingly, the increase in ash, protein and fat content found in cooked silver catfish fillets is explained by the reduction in moisture. While cooking methods affected mineral content of anchovy, cooking temperature did not affect. Cooking methods reduced moisture and increased the protein content in silver catfish (*Rhamdia quelen*). The ash content increased significantly whereas that of the minerals (Na, K, Ca, Mg, Fe, Zn and Mn) was not affected in all cooking methods. Na, Mg, and Zn contents of cooked fish fillets significantly decreased in Red mullet. In comparison to raw fish fillets, when grass carp (*Ctenopharyngodon idella*) was cooked there was an increase in protein, lipid and ash contents. Na, K, Mg, P and Zn contents of boiled fish fillets significantly decreased. Fish cooking, considering that Mg, P, Zn and Mn contents decreased in almost all cooking methods of rainbow trout (*Oncorhynchus mykiss*). The protein and ash contents increased in all cooked fish. The moisture content of cooked fish decreased. Mineral levels were affected by cooking methods, African catfish.

Cooking has statistically significant effect on the moisture content, Sodium, Manganese, Iron Zinc and Magnesium of Crucian Carp fish meal (Table 2). Cooking or heating has no statistically significant ($p>0.05$) effects on protein contents, fat, ash, Sodium and Potassium of fish meal. The cooked crucian carp fish meal had significantly ($p<0.05$) low moisture content (5.973±0.4813) as compared to uncooked one (7.0326±0.8826). Cooking has significantly increased ($p<0.05$) Manganese and Iron content as compared to uncooked Crucian Carp fish meal. However, cooking has significantly ($p<0.05$) lowered Zinc content as compared to uncooked one.

In Table 1 and 2, the moisture content and fat content of cooked both Common carp and Crucian carp is lower as compared to uncooked ones. The reason behind low moisture content and fat content in cooked fish offal rapture of fat deposits to release oil and pressing drained out water content. Cooking coagulate protein thereby liberating bound water and oil, separation by pressing yield press cake which contains 60-80% of the oil-free dry matter (protein, bones) and liquid phase (press liquor) which contains water, oil, dissolved and suspended protein, vitamins and minerals [9]. Pressing of the cooked offal is done to separate the bulk of the liquid fraction (press liquor) from the solid parts (press cake). This can be attained by pressing tightly the lid and tilting barrel containing cooked offal, so that the liquid fractions drain out. The main purpose of pressing is to squeeze out as much liquid (water and oil) as possible from the solid phase.

Pressing helps to accelerate the drying process.

The decrease in moisture content after heat treatments is caused by partial water loss through evaporation. Decreased moisture content has been described as the most important change causing significant protein increase in cooked fish fillets. Pointed out that the increase in protein, fat, and ash contents in fish after different cooking methods could be explained by water reduction [10], indicating an inverse relationship between water content and other nutritional components.

Fish species has statistically significant effect on the moisture content, Sodium, Potassium, Manganese, Iron and Zinc of fish (Table 3). Fish species has no statistically significant ($p>0.05$) effects on protein, fat and ash. The cooked common carp fish meal had significantly ($p<0.05$) high moisture content, crude protein, Potassium, Manganese and Zinc as compared to cooked Crucian carp. However, cooked common carp fish meal had significantly ($p>0.05$) low Sodium and Iron as compared to cooked Crucian carp.

The result obtained revealed, the crude protein content of tilapia and catfish is about (50.8% and 45.6%), fat content (9.2 and 8.8%), ash (29.5% and 37.6 %), the moisture content (12.8% and 15.4%), respectively. In the present study, moisture content of Common carp and Crucian carp is 6.6558±0.654 and 5.9731±0.048, protein content (64.23 ± 1.924 and 58.8839 ± 0.6717) and fat is (6.715±0.4415 and 7.3563±0.0719). Fishmeal contains typically 60 to 72 percent protein, 10 to 20 percent ash, 5 to 12 percent fat and has a high content of the fatty acids EPA and DHA; more commonly referred to as long chain omega-3s. The protein content of Common carp and Crucian carp is higher than Nile tilapia and African Catfish. Common carp has significantly ($p<0.05$) higher moisture content as compared to Crucian carp [11]. The protein content and fat content was statistically not affected ($p>0.05$) by fish species. Even though there is no statistically significant difference in protein content between Common carp and Crucian carp, the protein content of Common carp is higher than Crucian carp. This may be attributed to differences in the feeding habits, age, sex, breeding conditions and seasonal variations. These variations are closely related to the processing methods of raw material, food shortage, or physiological factors such as spawning or migrations, influence the chemical composition, occurring a higher variation of the lipid fraction . Crucian carp has significantly higher ($p<0.05$) ash content as compared to Common carp. Study conducted on the effects of cooking temperatures (55, 65, 75, 85, 95, and 100 °C) on sensory properties and protein hydrolysates were studied in crucian carp (*Carassius auratus*) soup. A cooking temperature of 85 °C was preferred for more excellent flavor and higher nutritional value of crucian carp.

Study was conducted to determine the effect of different cooking methods on the nutritional composition of Salmon and Chilean jack mackerel fillets. It was observed that Protein content in both salmon and Chilean jack mackerel significantly increased under the different cooking methods.

Fish species has statistically significant effect on Crude ash, Manganese, Iron and Zinc of fish (Table 4). Fish species has no statistically significant ($p>0.05$) effects Moisture content, protein, fat, Sodium and Potassium of uncooked fish [12]. The uncooked common carp fish meal had significantly ($p<0.05$) high Potassium, Manganese and Iron as compared to uncooked Crucian carp. However, uncooked common carp fish meal had significantly ($p>0.05$) low Crude ash as compared to cooked Crucian carp. The effect of dried and cooked common carp offal to feed common carp during which he observed that the crude protein (62 %) content was similar with the present finding, however, crude fat (14 %) and crude ash (9 %) differs from present study.

Table 3: Proximate and Minerals contents of Cooked Common carp and Crucian carp.

Parameters	Common carp	Crucian carp	P-value
Moisture Content	6.6558±0.654^a	5.9731±0.048^b	0.008
Crude Protein	64.23±1.924^a	58.8839±0.6717^a	0.05
Crude Fat	6.715±0.4415^a	7.3563±0.0719^a	0.430
Crude Ash	25.937±0.161^a	25.92±0.295^a	0.934
Gross energy (Kcal/ 100g)	317.355	301.7423	
Sodium	2518.21±10.2563^b	2705.1966±8.1913^a	0.009
Potassium	8579.6566±44.3587^a	8071.77±60.056^b	0.034
Manganese	54.3133±0.3894^a	42.56±1.8728^b	0.017
Iron	665.89±19.1836^b	1992.42±21.9^a	0.001
Zinc	531.75±1.798^a	405.8433±4.644^b	0.002
Magnesium	2570.35 ± 97.96^a	2316.86±46.61^a	0.205

Table 4: Proximate and Mineral contents of Uncooked Common carp and Crucian carp.

Parameters	Common carp	Crucian carp	P-value
Moisture Content	7.5028±0.19^a	7.032±0.05^a	0.097
Crude Protein	63.411±2.3616^a	57.432±6.352^a	0.517
Crude Fat	9.115±0.0357^a	10.034±0.715^a	0.405
Crude Ash	21.45±0.133^b	26.257±0.4412^a	0.004
Gross energy (Kcal/ 100g)	335.679	320.034	
Sodium	2472.34±4.0775^a	2561.6±28.1709^a	0.094
Potassium	8965.266±35.12^a	8466.5±157.139^a	0.060
Manganese	83.11±0.9063^a	53.3066±0.425^b	0.001
Iron	1707.72±40.47^a	676.2466±19.017^b	0.001
Zinc	369.74±1.46^a	550.92±10.216^a	0.002
Magnesium	2286.87±50.076^b	2797.22±76.42^a	0.047

Conclusion and recommendation

From the present study, it was concluded that cooking has statistically significant effect on the moisture content, fat content and ash contents. Cooking or heating has no statistically significant effects on protein contents of fish meal. Common carp has significantly higher moisture content as compared to Crucian carp, however, the protein content and fat content was statistically not affected by fish species [13-15].

It is recommended that process control is necessary for producing high quality fish meal. Excess temperature for prolonged periods in the cooking, evaporating and drying should be avoided since fish protein is sensitive to excessive heat. When the flesh is cooked at high temperatures, the proteins on the surface of fish flesh coagulated. On the other hand, when the cooking temperature is lower, the denaturation of muscle protein in the fish flesh might not complete and the soluble protein hydrolysates had not been dissolved sufficiently. Cooked offal of common carp has better protein content hence it preferred to be used as an animal feed over Crucian carp.

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References

1. Al–Zahiri AJM, Al-Shawi SA (2021) Effects Of Dried Raw Fish Offal Meals And Cooked As Animal Protein In Diets Of Common Carp (Cyprinus Carpio L) On Growth Criteria. Plant Archives 21: 59-62.
2. Chiu A, Li L, Guo S, Bai J, Fedor C, et al. (2013) Feed and fishmeal use in the production of carp and tilapia in China. Aquaculture 414: 127-134.
3. Crexi V T, Souza Soares L A, Pinto L A (2009) Carp (Cyprinus carpio) oils obtained by fishmeal and ensilage processes: characteristics and lipid profiles. Int J Food Sci tech 44: 1642-1648.
4. Ersoy B, Ozeren A (2009) The effect of cooking methods on mineral and vitamin contents of African catfish. Food Chem 115: 419–422.
5. Ferguson C, Kuhn D, Murphy B, O'Keefe S, Phelps Q, et al. (2020) Characterizing Biometrics and Nutrient Profiles of Fillet and Offal Components to Better Utilize Harvests of Invasive Carp in the US. J Food Secur 8: 52-65.
6. Gall KL, Otwell WS, Koburgier JA, Appled H (1983) Effects of four cooking methods on the proximate, mineral and fatty acid composition of fish fillets. J Food Sci 48: 1068-1074.
7. Gokoglu N, Yerlikaya P, Cengiz E (2004) Effects of cooking methods on the proximate composition and mineral contents of rainbow trout (Oncorhynchus mykiss). Food Chem 84: 19-22.
8. Golgolipour S, Khodanazary A, Ghanemi K (2019) Effects of different cooking methods on minerals, vitamins and nutritional quality indices of grass carp (Ctenopharyngodon idella). Iran J Fish Sci 18: 110-123.
9. Hosseini H, Mahmoudzadeh M, Rezaei M, Mahmoudzadeh L, Khaksar R, et al.(2014) Effect of different cooking methods on minerals, vitamins and nutritional quality indices of kutum roach (Rutilus frisii kutum). Food chem 148: 86-91.
10. Indrayan AK, Sharma S, Durgapal D, Kumar N, Kumar M (2005) Determination of nutritive value and analysis of mineral elements for some medicinally valued plants from Uttaranchal. Curr sci 89: 12-52.
11. Koubaa A, Mihoubi NB, Abdelmouleh A, Bouain A (2012) Comparison of the effects of four cooking methods on fatty acid profiles and nutritional composition of red mullet (Mullus barbatus) muscle. Food Sci Biotech 21: 1243-1250.
12. Marimuthu K, Thilaga M, Kathiresan S, Xavier RHMH, Mas RHMH (2012) Effect of different cooking methods on proximate and mineral composition of striped snakehead fish (Channa striatus, Bloch). J food sci tech 49: 373-377.
13. Poulter R G, Doe P E, Olley J (1982) Isohalic sorption isotherms. J food tech 17: 201-210.
14. Uran H, Gokoglu N (2014) Effects of cooking methods and temperatures on nutritional and quality characteristics of anchovy (Engraulis encrasicholus). J food sci tech 51: 722-728.
15. Ward A, Wignall J, Windsor M L (1977) The effect of cooking temperature and applied pressure on the release of liquor from fish. J Sci Food Agric 28: 941-947.