CHEMICAL COMPOSITION AND SENSORY EVALUATION OF WILD AND CULTURED *OREOCHROMIS NILOTICUS* AND *CLARIAS GARIEPINUS* IN NORTHERN GHANA

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ABSTRACT
Fish is a delicacy in many Ghanaian homes but most consumers lack knowledge of their nutritional levels. The objective of this study was to assess the nutritional composition and consumer preference of wild and cultured species of Oreochromis niloticus and Clarias gariepinus. Moisture, crude protein, crude fat and ash were determined in the Spanish Laboratory at the University for Development Studies, Nyankpala Campus using procedures of the Association of Official Analytical Chemists (AOAC). Consumer acceptability of fish flesh was evaluated by twenty trained panelists using samples prepared at the Meats Unit Limited of the University for Development Studies, Nyankpala Campus. Moisture content of the wild (77.83 ± 0.60%) and cultured (78.50 ± 2.34%) O. niloticus showed no significant difference ($p > 0.05$). Similarly there was no significant difference ($p > 0.05$) in moisture content of the wild (81.84 ± 2.75%) and cultured (74.50 ± 4.16%) C. gariepinus. The results also showed no significant difference ($p > 0.05$) in protein content of the wild (75.17 ± 1.30%) and cultured (77.67 ± 1.23%) O. niloticus as well as wild (60.83 ± 4.62%) and cultured (54.54 ± 2.79%) C. gariepinus. Fat and ash contents were significantly different ($p < 0.05$) in wild and cultured O. niloticus but not significantly different in the C. gariepinus samples. Sensory ratings for colour, odour, flavour and tenderness of O. niloticus generally indicated higher preference for the cultured than the wild species. Conversely, the wild C. gariepinus was more preferred to the cultured species. The levels of nutrients and consumer acceptability of wild and cultured species of both fish species were satisfactory.

Keywords: ***Chemical composition, Oreochromis niloticus, Clarias gariepinus, Sensory assessment and Acceptability***

INTRODUCTION
The global consumption of fish and derived fish products has greatly increased during recent decades due to a number of factors including low cholesterol content when compared with meat and thus often recommended for consumption especially among the adult population (Wim *et al*., 2007; Adeniyi *et al*., 2012). Also, Fish contains vitamin A, vitamin B and an excellent source of omega 3 fatty acids. Regular consumption of fish can reduce the risk of various diseases and disorders such as asthma, prostate diseases, diabetes, eye diseases, depression, heart diseases, stroke and premature birth (Hauser, 2015).Fish is consumed as an alternative source of protein due to the higher cost of meat as other sources of animal protein (Omolara and Omotayo, 2009).

In Ghana, *Oreochromis niloticus* and *Clarias gariepinus* are widely consumed across many lands (towns and villages) with varied cultures. Theses fishes are obtained from cultured and captured water systems. Ashraf *et al*. (2011) reported that the chemical composition of fishes from culture and capture could be different due to the variation in the source of food. Whiles cultured fish are provided with nutrient rich foods, captured fish on the other hand depends totally on natural foods for its sustenance. Body composition is therefore a true reflection of the fish feeding habit and the type of food available. Though the most widely cultured and preferred-fish species in Ghana are *Oreochromis niloticus* and *Clarias gariepinus*, little is known about their comparative benefit in terms of chemical composition and fillet acceptability. This study therefore, aimed at assessing the protein, moisture, fat and ash levelsas well as consumer preference of wild and cultured *O. niloticus* and *C. gariepinus* in the northern part of Ghana.

METHODOLOGY

Sampling sites

Samples for the study were taken from Tono and Libga reservoirs in the Upper East and Northern regions respectively. Tono is located in Navrongo within the Kassena-Nankana District of the Upper East Region of Ghana. The project (Tono irrigation project) lies in the Guinea Savannah ecological zone of Ghana lying within latitude 10º 52′ North and longitude 1º 08′ West covering an estimated land mass of 1,674 km^2.The Libga Reservoir (9º 35′ N, 0º 51′ W) is located in the Savelugu-Nanton Municipal has an irrigated area of 48 hectors.

Fish sampling and preparation

Three samples each of *O. niloticus* and *C. gariepinus* both wild and cultured were purchased from fishermen fishing from the Tono and Libga reservoirs and fish farmers in March, 2015. The weight and total length of ten (10) specimens of *O. niloticus* specimen ranged 100 – 350 g and 15 – 21 cm respectively. The weight and total length of ten (10) specimens of *C. gariepinus* ranged 420 – 1,500 g and 39 – 55 cm respectively. Fish samples were gutted, washed and transported to the University for Development Studies, Spanish Laboratory, Nyankpala campus preserved in iced cubes contained in an ice chest. On arrival, both samples of wild and cultured fish from the respective sites were divided into two each one for chemical analysis (5 specimens for each species) and the other for sensory analysis (5 specimens for each species).

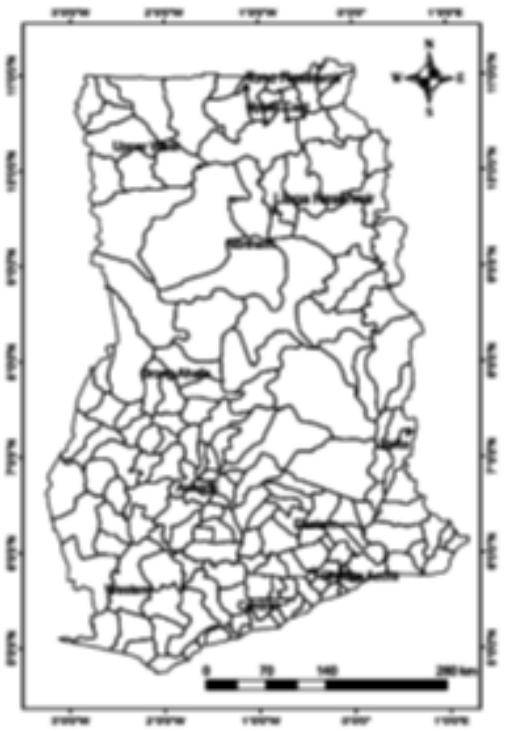

Figure 1: Map of Ghana showing Tono and Libga reservoirs

Chemical analysis

Parameters such as moisture, crude protein, fat and ash were investigated. Each fish sample in its fresh state was subjected to chemical analysis in triplicate using the procedures of the Association of Official Analytical Chemists (AOAC) (1990) for moisture, crude protein, fat and ash.

Procedure for moisture determination

Moisture cans were oven dried for 30 minutes at a temperature of 105 °C, and cooled in a desiccator for 30 minutes. Weights of cans were recorded and 3 g of each sample weighed into the cans. Cans with samples were oven dried for 2 hours at same (105 °C), temperature. Samples upon drying and cooling in a desiccator for 30 minutes were weighted and weight difference recorded for moisture. The percentage of moisture was determined using the formula below:

$$\% \text{ Moisture} = \frac{\text{Fresh Weight - Dried Weight}}{\text{Fresh Weight}} \times 100$$

(AOAC, 1990)

Procedure for fat extraction

A fat extractor was pre-heated for approximately 30 min before use; temperature was regulated to 125°C to heat up the machine. Thimbles were cleaned with petroleum ether as a degreasing solvent and inserted into extraction cartridges placed in the support rack. Three grams (3 g) each of ground samples of various codes were weighed and placed in extractor cartridge (thimble) containing cotton wool. Clean dry aluminum beakers free from fat were used. Beakers were cleaned with ether and oven dried at a temperature of 105^{o}C for 30 minutes, cooled in a desiccator for 30minutes. Beakers were weighed before transferring to beakers racks. Rack with tubes and support-cartridges were inserted in the cut-out profile in the front of the extraction unit. Tube supported cartridges were placed in the rack. With the help of the magnetic clip, cartridges of the rack supported cartridge were transferred to the tube-supported cartridges. In the extraction unit, levels of each column were located in position (rising). Tube-supported cartridge were grabbed with the aid of the transport handle and introduced into the extraction unit taking care that each cartridge adhered to the magnet on each column.

About 50 ml of ether was added to each aluminum beaker. By means of the beaker rack the beakers were introduce into each column, the lever was lower and at the same time beakers align so that they were inserted under the piece of Teflon of each column. The extraction was done. From this point the ether cycle began; boiling-evaporation-condensation, subjecting the samples to the solvent action of the ether, in the gas as well as the liquid state, extracting the fat from the sample into the aluminum beaker. Levers of the extractor were turned to a boiling position (in this position the samples are submerged into boiling ether) for about 30 – 45minutes and turned to a rinsing position (in this position the samples are subjected to the ether vapour and to the liquid ether condensed from the cooled reflux column) for about 40 – 60 minutes. The levers were then turned to a recovery position (a position that causes the ether that comes from the condenser and not to go back into the aluminum beaker by retaining it in the upper part of the collar) for about 5-10 minutes.

Extracted fat in the aluminum beakers were heated by switching on the air heater unit (fixed to the fat extracting device) to eliminate remnants of ether by passing an air current over the aluminum beaker surface. Afterwards, fat collected in the beakers were weighed again. The difference in weight thus weight of beakers and weight of beakers with fat gave the level of fat in samples.

The percentage fat was calculated as follows:

$$\% \text{ Fat} = \frac{\text{Weight of can/beaker and fat - Weight of can/beaker}}{\text{Weight of sample}} \times 100$$

(AOAC, 1990)

Procedure for ash determination

Ceramic crucibles were oven dried at a temperature of 105˚C for 30 minutes and cooled in a desiccator for 30 minutes. Weights of crucibles were taken and 2g of each sampled weighed**.** Samples were heated in a furnace at a temperature of 550˚ for about 3 hours for samples to turn completely into ash.

The percentage of ash was determined as follows:

$$\% \text{ Ash} = \frac{\text{Weight of crucible and ash - Weight of Crucible}}{\text{Weight of sample}} \times 100$$

(AOAC, 1990)

Procedure for determining crude protein

Crude protein was determined using micro Kjeldahl method; this method involved three steps as follows:

i) **Digestion** – 1geach of dry fish samples in triplicate groups was weighed into digestion tubes of 250 ml. Two (2) Kjeldahl tablets were put into each tube and 13ml of concentrated sulphric acid added. Rack with digestion tubes were inserted into a digestion block heater under a fume hood and exhaust manifold installed, connected to water aspirator. Sample were digested at a temperature of 420˚C until liquid turned transparent, then rack was removed with exhaust manifold from digester and allowed to cool to room temperature under fume hood. Exhaust manifold was removed and tubes separately transferred to distillation unit.

ii) **Distillation** – Adding 65 ml of water and 35 ml of 40% sodium hydroxide solution to each sample treatment, samples were distilled and condensed liquid collected in Erlenmeyer flask with 10 ml indicator solution (boric acid).

iii) **Titration** – Condensed liquid was titrated with 1M hydrochloric acid (HCL) until colour turned pink. Then the titre value was recorded and crude protein calculated from the formula:

$$\%N = \frac{1.4007 \times (V_a - V_b) \times N}{W}$$

V_a: Volume of acid used for sample titration
V_b: Volume of acid used for the blank
N: Normality of acid
W: sample weight in grams
1.4007: Conversion factor milli-equivalent weight of Nitrogen and N
Therefore
% Protein = % N x 6.25 (AOAC, 1990)

Sensory assessment

Sensory attributes such as colour, flavour, odour, tenderness and overall acceptability were assessed on a 9-point hedonic scale. (Omolara and Omotayo, 2009). Fish samples were grilled in an oven at a temperature of 105˚C for about an hour. Samples were then allowed to cool and wrapped in aluminum foils based on treatment codes.

After which a 20-trained panel was set to assess samples using a 9-hedonic sensory scale form. Each panellist was served with 10 g each of fish sample and instructed to taste and evaluate the sample using an evaluation sheet in a sensory evaluation booth. Bread and water were supplied to panellists for refreshing their mouths before tasting subsequent samples.

Data analysis

Microsoft Excel (2013) was used for the statistical analysis of the chemical composition of the fishes. Means of the significance were separated using the student t-test at 95% confidence value ($p < 0.05$). The 9-hedonic scale test was compiled into points of occurrence and bar charts used to present attributes of fish species for easy comparison of sensory assessment.

RESULTS

Chemical analysis

The moisture content was higher in the cultured species (78.50 ± 2.335 %) than in the wild (77.83 ± 0.601 %) without significant difference ($p > 0.05$). Moisture in wild (81.84 ± 2.75 %) *C. gariepinus* were higher although not significantly different compared to that of the cultured (74.50 ± 4.16 %). For *O. niloticus*, fat content was higher (5.33 ± 0.494 %) in the cultured species than 1.00 ± 0.258 % in the wild with a high significant difference (Table 1). For *C. gariepinus* fat levels ranged from 7.67 ± 0.71% to 7.92 ± 2.24 % with no significant difference (Table 1).

The ash content for *O. niloticus*was higher (6.33 ± 0.211 %) in the wild species than in the cultured (4.33 ± 0.211 %) with a high significant

Table 1: Chemical composition of wild and Cultured *O. niloticus* and *C. gariepinus*

Parameter	Wild fish (Mean ± SEM)	Cultured fish (Mean ± SEM)	P-value	Significance
Oreochromis niloticus				
% Moisture	77.83 ± 0.601	78.50 ± 2.335	0.794	NS
% Fat	1.00 ± 0.258	5.33 ± 0.494	0.000	S
% Ash	6.33 ± 0.211	4.33 ± 0.211	0.003	S
% Crude protein	75.17 ± 1.302	77.67 ± 1.229	0.262	NS
Clarias gariepinus				
% Moisture	81.84 ± 2.75	74.50 ± 4.16	0.370	NS
% Fat	7.67 ± 0.71	7.92 ± 2.24	0.190	NS
% Ash	4.67 ± 0.47	4.00 ± 0.26	0.300	NS
% Crude protein	60.83 ± 4.62	54.54 ± 2.79	0.350	NS

NS = not significant, S = significant and SEM = Standard error of mean

difference. That of *C. gariepinu*s ranged from 4.67 ± 0.47 % to 4.00 ± 0.26 %.

The protein content for *O. niloticus* was higher in the cultured species (77.67 ± 1.229 %) than in the wild (75.17 ± 1.302 %) without significant difference. Also, protein levels (Table 1) revealed higher levels in wild (60.83 ± 4.62%) than in farmed (54.54 ± 2.79 %) *C. gariepinus*.

Sensory Assessment

Colour and odour

Colour scores for *O. niloticus* for both wild (15) and cultured (19) fish were highest for 'like moderately' among other attribute descriptions. Attribute descriptions of 'like slightly' and 'like very much' followed closely but with the scores for cultured fish higher than their counterpart wild fish (Figure 2). A few scores were recorded for wild fish but with no scores for cultured fish for attribute descriptions of 'neither like nor dislike', 'dislike slightly' and 'dislike moderately'. For *C. gariepinus* (Figure 2), wild fish were rated highest for the attribute description of 'like extremely' (28). Cultured catfish recorded its highest score for the attribute description of 'like moderately' (21). There were no scores for 'neither like nor dislike', 'dislike moderately', 'dislike extremely' and 'dislike very much'.

The odour scores for *O. niloticus* were higher for cultured fish than the wild counterpart (Figure 2). Attributes descriptions 'dislike moderately' to 'dislike extremely' had scores ranging between 1 and 5 for both cultured and wild *O. niloticus*. In the case of *C. gariepinus,* scores for 'like very much' (15) and 'like moderately' (21) recorded the highest scores for cultured fish. 'Like very much' (18) and 'like extremely' (15) recorded the highest scores for wild fish. There were no (zero) scores for 'neither like nor dislike', 'dislike moderately', 'dislike extremely' and 'dislike very much' (Figure 2).

Flavour and Tenderness

'Like extremely', 'dislike moderately' and 'dislike extremely' registered low scores for both wild and cultured of *O. niloticus* (Figure 3). *Clarias gariepinus* preference for flavour was highly expressed in the wild fish for the attribute description of 'like extremely' (26). 'Like slightly' (19) scored the highest for cultured fish. There were no (zero) scores for 'dislike slightly', 'dislike moderately', 'dislike extremely' and 'dislike very much' (Figure 3).

Figure 3 shows a nearly the same preference for tenderness for both wild and cultured *O. niloticus.* 'Like slightly' for wild (14) fish had the

highest rating scoring while‘ like very much’ recorded the highest rating/scores for cultured fish (12). Non-preference attributes such as ‘dislike moderately’ and ‘dislike very much’ recorded lower scores for both wild and cultured fish. There was zero score for ‘dislike extremely’ value for both the wild and cultured fish. For *C. gariepinus*, panel preference for tenderness was highest for farmed fish (22) for the attribute description ‘like moderately’ and highest for wild fish for attribute description of ‘like very much’. ‘Dislike moderately’, ‘dislike extremely’ and ‘dislike very much’ for both farmed and wild fish registered zero scores as shown in Figure 3.

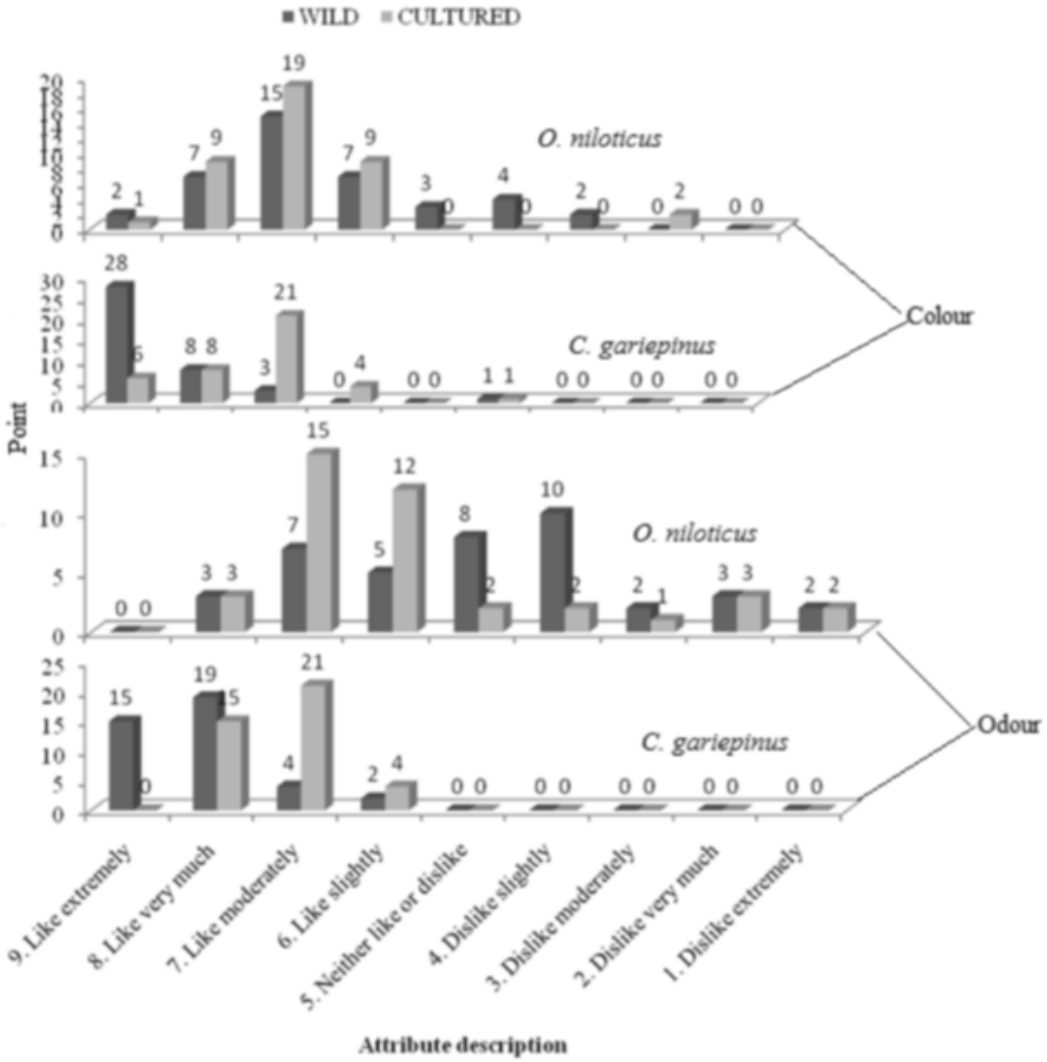

Figure 2: Colour and odour ratings for *Oreochromis niloticus and Clarias gariepinus* during sensory assessment

Overall acceptability

Figure 4 shows the scores on overall acceptability for *O. niloticus*. 'Like moderately' for cultured fish (14) had the highest rating while' like slightly' scored the highest rating for the wild fish (12). 'Neither like nor dislike' followed closely with a rating of 11 for wild fish. On the other hand, Figure 4 shows the scores for *C. gariepinus*. 'Like extremely' (25) recorded the highest rating for wild fish while' like slightly' (18) recorded the highest rating for farmed fish. There was no score for 'neither like nor dislike', 'dislike moderately', 'dislike extremely' and 'dislike very much' for both farmed and wild fish.

DISCUSSION

The main purpose of these findings was to discover the chemical composition as well as consumers' preference to wild and cultured *O. niloticus* and *C. gariepinus* in northern Ghana considering fish from Tono and Libga areas.

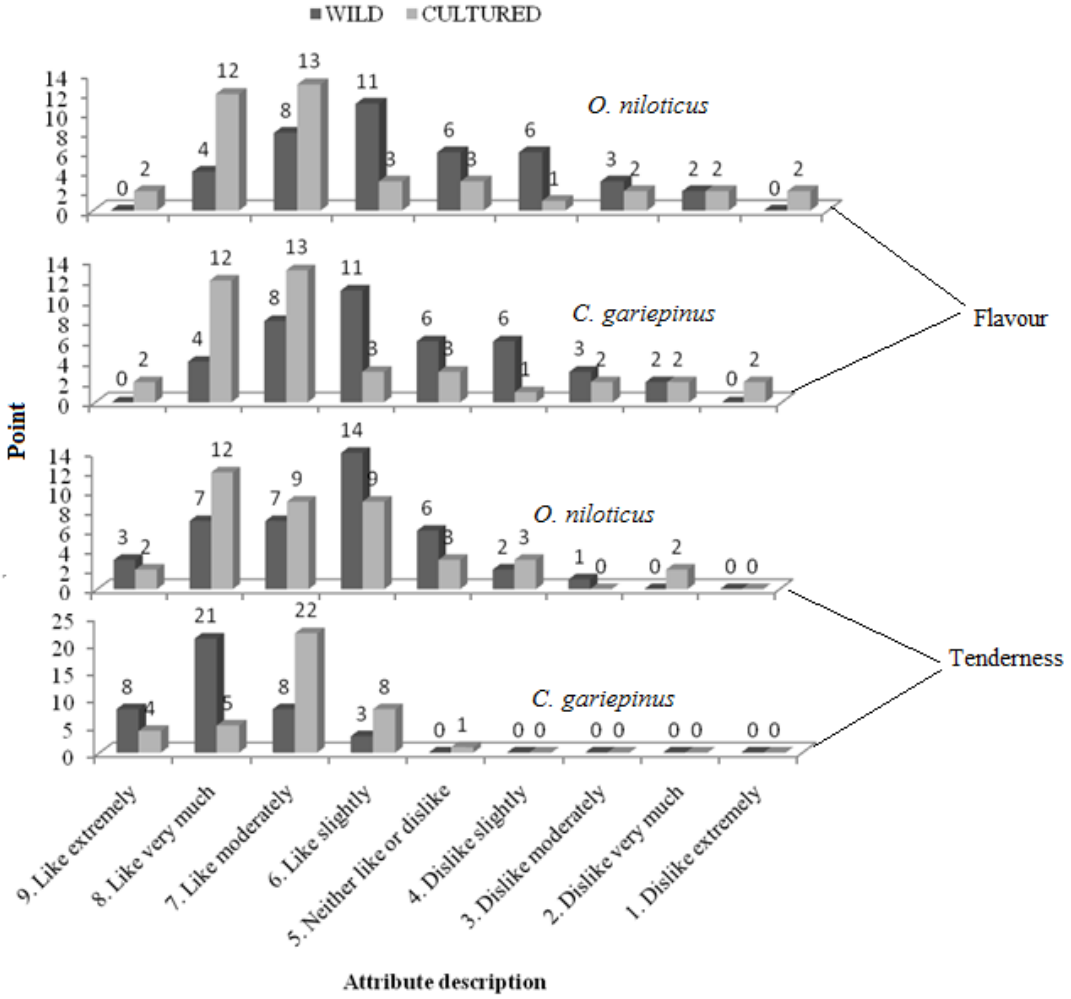

Figure 3: Flavour and tenderness ratings for *Oreochromis niloticus and Clarias gariepinus* during sensory assessment

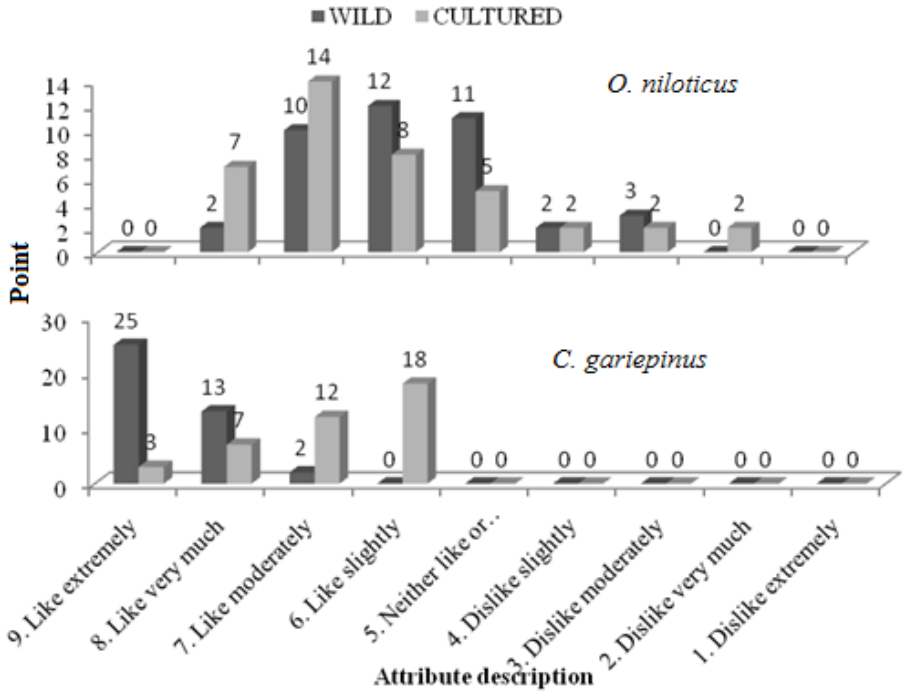

Figure 4: Overall acceptability ratings for *O. niloticus* and *C. gariepinus* during sensory assessment

Chemical composition of fish

The nutritional composition of both cultured and wild *O. niloticus* and *C. gariepinus* as shown in Table 1 indicates the rich nutrient nature of fish as good animal protein source. This supports a well-known fact that fish represents a high-quality nutritional source (Sidhu, 2003). The significant differences in the fats and ash levels in cultured and wild *O. niloticus* is a clear indication that the same fish species growing from different environments could have their nutrient composition affected. The season, age, level of maturity, environmental factors, availability food and lipid, protein, energy contents of commercial feed have a significant effect on the proximate composition of fish (Kayim *et al.,* 2011). *Oreochromis niloticus* and *C. gariepinus* from culture and wild environments as shown in Table 1 is a confirmation of the inference drawn by Kayim *et al.* (2011).

Moisture levels for both cultured and wild *O. niloticus* and *C. gariepinus* were not significantly ($p > 0.05$) different. This means that the moisture content of both fish species regardless of the culture system has no influence on the amount of water the fish will contain. This implies that when there is a need for preservation the same principles must be applied. Moisture content from wild and cultured species of *O. niloticus* (77.83 ± 0.601 % and 78.50 ± 2.335 %) fall within the range of moisture contents reported by Galhom (2002) for same fish species from Egyptian waters which ranged between 70.00 and 79.00%. Moisture content of the wild (81.84 %) *C. gariepinus* recorded in the study was higher than that of the cultured (74.50 %) species. Taiwo *et al.* (2014) reported a similar trend with 77.83 % and 75.58 % for wild and farmed respectively.

In this study, a significantly ($p < 0.05$) lower fat content in wild fish was observed as compared to the cultured fish as presented in Table 1. This is in conformity with the report by Alasalvar *et al.* (2002) and Grigorakis *et al.* (2002) attributing it to the fact that fat content in fish flesh is directly related to the nutrition of the fish. In comparing wild and farmed fish, higher lipid contents are found in farmed fish than those in the wild because of the accessible and well formulated diets (Orban *et al.,* 2003). The lipid content of wild fish, however, cannot be manipulated by the fisherman and will be mainly influenced by the food type and availability, among other factors. There were no significant differences in fat content of *C. gariepinus*; it was unclear why this was so.

The higher ash content (4.00 % – 6.33%) could be attributed to a wide range of feed for wild species than the cultured. Regarding this, Elzaeem *et al*. (2012) reported that the ash concentration of fish is affected by parameters such as feed type, level of dietary intake and growth. In general, tilapias are macrophyte-feeders, feeding on a diverse range of filamentous algae and plankton (Toguyeni *et al*., 1997). The ash content of the wild *C. gariepinus* (4.67%) was higher than that of the farmed (4.00 %) but was not significant ($P > 0.05$).

Protein content does not vary as often as lipid, since it is not impacted by diet, but mainly is determined by the species type, genetic characteristics and size (Morris, 2001). From Table 1 crude protein content of wild *O. niloticus* (75.17 ± 1.302 %) was lower than in the cultured (77.67 ± 1.229 %) but was not significantly different ($P > 0.05$). This could be explained by the fact that they are of the same species. This also implies that if both wild and cultured *O. niloticus* provides same amount of protein value to consumers. This corroborates Johnsen (1991) who explained that in general both farmed and wild fish have essentially the same protein content. In the case of the crude protein content of *C. gariepinus,* the wild (60.83%) fish was slightly higher than that of their farmed (54.54 %) counterparts though not significantly different ($P > 0.05$). This result contradicts the findings of Adeosun *et al.* (2014) and Taiwo *et al.* (2014).

Sensory assessment of fish

Colour is an important factor impacting consumer's acceptability. In general, the ratings for colour for both cultured and wild *O. niloticus* and *C. gariepinus* were accepted more than were rejected as the ratings were highest for attribute description of 'like moderately' to 'like slightly'. The results in this study provide indications that the culture environments do not negatively affect the colour of fish meat. It may also mean that the foraging ability of these fishes is such that it does not affect negatively on the colour of flesh produced hence acceptability is very wide.

In Figure 2, more 'like' ratings were recorded for cultured *O. niloticus* than its wild counterparts. Clearly, if not by chance it implies that the culture environment may influence the odour of fish to be accepted by consumers or to be rejected. Adu-Adjei *et al.* (2014) indicated that, aroma (odour or smell) gives an indication of the degree of attraction or repulsion of consumers to food substance. Consumers of a product are attracted or repelled to it by means of its odour. Pleasing aromas attract consumers while irritating odour repels them (Agbolosu *et al*., 2014). *Clarias gariepinus* as in Figure 2 indicated more 'like' ratings for the wild fish and 'dislike' ratings for the cultured fish. This could be attributed to the level of maturity and nutrition of the diet eaten or provided. Catfishes in the wild have the liberty to forage on what they need, cultured catfishes on the other hand would have to depend on what is been provided.

Flavour considers all the compounds in food that have taste, the interaction between these compounds and the effect on human senses. Cultured *O. niloticus* (Figure 3) had better flavour than its wild counterpart. On the other hand, wild *C. gariepinus* (Figure 3) had better flavour than its cultured one. The reasons for varied flavours in both fishes cannot be explained within the context of this work. There may be the need to fur-

ther investigate the chemical compounds in these fishes to establish the bare facts. Work done by Safari *et al.* (2001) showed how the flavour affects the acceptability of fish.

The reason why wild fish of *O. niloticus* (Figure 3) was preferred to its cultured counterpart is beyond the scope of this study. Contrarily, Haard (1992) reported that the cultured fish had more tender flesh than wild fish. The differences in tender ratings were attributed to reasons such as the lipid content and amount of exercise. For *C. gariepinus,* (Figure 3), ratings by the panel showed preference for wild fish than the cultured fish. The differences observed in this study could not be explained.

CONCLUSION

There was no significant difference in moisture and protein content of both cultured and wild *O. niloticus*. There was however, significant difference in the fat and ash level of *O. niloticus*. For the chemical composition of *C. gariepinus,* no significant differences were observed between the cultured and wild species.

Considering colour, odour, flavour tenderness/ texture and overall acceptability, cultured *O. niloticus* fish was more preferred to the wild species by panellists. For *C. gariepinus*, wild species was more acceptable compared to cultured species.

Further studies on the same fishes with a larger sample size in a wider study area over a wider season will provide more information on chemical and sensory superiority of fishes.

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REFERENCES

Adeniyi, S.A., Orikwe, C. L. Ehiagbonare, J. E. and Joshia, S. J. (2012). Nutritional composition of three different fishes (*Clarias gariepinus, Malapterurus electricus* and *Tilapia guineenisis*). Pakistan Journal of Nutrition, 8, 793-797.

Adeosun, O., Olukunle, O. and Akande, G. R. (2014). Proximate composition and quality aspects of iced wild and pond raised African catfish (*Clarias gariepinus*), 6(13), 32 p.

Adu-Adjei, S., Adzitey, F., and Teye, G. A. (2014). The effect of "Prekese" (Tetrapleuratetraptera) pod extract on the sensory and nutritional qualities of pork sausage. Global Journal of Animal Research, 2(1), 52-57.Agbolosu, A. A., Moses, T., and Adam, R. I. (2014). Effects of replacing maize with graded levels of boiled mango kernel meal on the carcass and sensory characteristics of indigenous guinea fowl (N*umida meleagris*) meat. Global Journal of Animal Research, 2 (4), 345-350.

Alasalvar, C., Taylor, K. D. A., Shahidi, F. (2002). Comparative quality assessment of cultured and wild sea bream (*Sparus aurata*) stored in ice. Journal of Agricultural and Food Chemistry, 50, 39-45.

AOAC (1990). Official methods of analysis. 15th Edn., K. Holdrick (Ed.). Association of Official and Analytical Chemists, Virginia, U.S.A, pp. 125-291.

Ashraf, M., Z. Asma, A. Rauf, S. Mehboob, and A.Q. Naureen. 2011. Nutritional Values of Wild and Cultivated Silver Carp (*Hypophthalmichthys molitrix*) and Grass Carp (*Ctenopharyngodon idella*). International Journal of Agriculture and Biology, 13 (2):210-214

El-zaeem, S. Y., Ezzat, E. T. N. and Talent, N. A. (2012). Effect of direct injection of Shark DNA into skeletal muscles on the productive performance characteristics of red tilapia (*Oreochromis* sp.) fed at different dietary requirement. African Journal of Agricultural Research, 7, 2456-2462.

Galhom, G. F. A. M (2002). Chemical and technological studies on some dried fish products. M. Sc. Thesis. Fac. Agric., Cairo Univ., Cairo, Egypt.

Grigorakis, K., Alexis, M. N., Taylor, K. D. A. and Hole, M. (2002).Comparison of wild and cultured gilthead sea bream (*Sparus aurata*); composition, appearance and seasonal variations. International Journal of Food Science and Technology, 37, 477-484.

Haard, N. F. (1992). Control of chemical composition and food quality attributes of cultured fish. Food Research International, 25: 289-307.

Hauser, A. (2015). Seven life-enhancing reasons to eat fish. Available: www. everydayhealth.com/diet-nutrition/life-enhancing-reasons-to-eat-fish.aspx [Accessed: 31/07/ 2015].

Johnsen, P. B. (1991). Aquaculture product quality issues. Journal of Animal Science, 69,4209-4215.

Kayım, M., Öksüz, A., Özyılmaz, A., Kocabas, M., Can, E., Kızak, V. and Ateş, M., (2011). Proximate composition, fatty acid profile and mineral content of WBT (*Salmo-trutta*sp.) from Munzur River in Tunceli, Turkey. Asian Journal of Chemistry, 23 (8), 3533 3537.

Morris, P. C. (2001). "The Effects of nutrition on the composition of farmed fish". In: S. C. Kestin and P. D. Warris (Eds.), Farmed Fish Quality, Fishing News Books, London. pp. 161-179.

Omolara, O. O. and Omotayo, O. D. (2009). Preliminary studies on the effect of processing methods on the quality of three commonly consumed marine fishes in Nigeria. BIOKEMISTRI, 21(1), 1-7.

Orban, E., Nevigato, T., Di Lena, G., Casini, I., and Marzetti, A. (2003). Differentiation in the lipid quality of wild and farmed seabass (*Dicentrarchus labrax*) and gilthead seabream (*Sparus aurata*). Journal of Food Science, 68(1), 128-132.

Safari, E., Fogarty, N. M., Taylor, P. J. and Hopkins, D. L. (2001). Genetic parameters for meat quality and Carcass traits in Australian merino sheep. Proc. Association Advancement Animal Breeding Genetics. 14, 115-118.

Sidhu, K. S. (2003). Health benefits and potential risks related to consumption of fish or fish oil. Regulatory Toxicology Pharmacology, 38, 336-344.

Taiwo, O. E., Usman, K., Ogono, T. H. and Osoniyi, R. O. (2014). Proximate and lipid profile analysis of cultured and wild African catfish, *Clarias gariepinus* [BURCHELL]. Ife Journal of Science, 16(1), 133-142.

Toguyeni, A., Fauemneau, B., Bonjand, T., Fostier, A., Kuha, E. Moland, K. and Baroillar, J. (1997). Feeding behaviour and food utilization in tilapia, *Oreochromis niloticus:* Effect of sex ratio and relationship with endocrine station. Physiology and Behaviour, 62: 273-279.

Wim, V., Isabelle, S., Karen, B., Stefaan, D. H. and John, V. C. (2007). Consumer perception versus scientific evidence of farmed and wild fish: exploratory insights from Belgium. Aquaculture International, 15:121 –136.