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NUTRITIONAL QUALITIES ASSESSMENT OF TILAPIA FISH *(TILAPIA QUINEENSIS)*

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ABSTRACT

Proximate, mineral and amino acid composition as well as functional properties of Tilapia fish (*Tilapia quineensis*) were studied using standard analytical techniques. The results gave proximate composition in percentage as: total ash (8.2), organic matter (91.8), moisture (12.5), crude protein (56.9), crude fat (17.6) and carbohydrate (4.8) while crude fibre was not in the detectable range. Mineral composition (mg/100g sample) of Ca, Na, K, Mg, Fe, Zn, Mn, Cu, Cr and Pb were 172.34, 2.2, 1.4, 11.9, 5.3, 0.4, 0.5, 0.7, 1.2 and 3.7, respectively which showed that Ca was the most highly concentrated mineral. The total amino acid was 88.3g/100g crude protein while Lys was the most highly concentrated essential amino acid (7.2g/100g crude protein). The fish sample had a balanced content of essential amino acid in Ile, Lys, Met + Cys, Phe + Tyr and Thr, with respect to the FAO pattern while supplementation may be required in Leu, Met + Cys and Val. The calculated isoelectric point (pI) was 5.1, predicted protein efficiency ratio (P - PER) was 2.12 and first limiting amino acid was Met + Cys. The results of functional properties were: foaming capacity (3.9%), foaming stability (2.6%, 8h), water absorption capacity (220.1%), oil absorption capacity (230.3%), oil emulsion capacity (55.0mlg^{-1}), oil emulsion stability (46.0 mlg^{-1}, 12h), lowest gelation concentration (8%) and bulk density (410gL^{-1}). The overall results showed that *Tilapia quineensis* could therefore be a good source of protein and could supplement cereal diet in raising the biological value significantly.

Keywords:- *Tilapia quineensis, nutritional qualities, assessment.*

INTRODUCTION

Tilapia fish (*Tilapia quineensis*) also of the family *Clariidae,* is a euryhaline species found along the west coast of Afica. The usual colouration is shiny, dark greenish yellow on the back and flanks becoming lighter in shade near the abdomen (Philippart & Ruwet, 1982).

The lower lip is white. All scales on the flanks have a black spot at the base. The dorsal fin is grey and blended with lighter coloured spots and a distinctly shaded upper and lower portion (Dadzie, 1981). *Tilapia quineensis* (*T. quineensis*) has been found to be closely related to *Tilapia zilli* but geographically separated from other similar species such as *Tilapia rendalli, Tilapiacongica* (Philippart & Ruwet, 1982). *Tilapia zilli* has two horizontal dark bands but *Tilapia quineensis* does not. *Tilapia quineensis* is an opportunistic feeder, apparently able to consume and digest a variety of food items (Fagade, 1971). The stomach pH values have been reported to be extremely low (1.0 to 3.7) with 75% of the observations being less than 2.0. A pH value of less than 2 was reported to be considerably helpful in the digestion of algae and bacteria (Payne, 1978). *Tilapia quineensis* is considered a relatively stenothermal species with a temperature range of 14 to 33°C (Philippart & Ruwet, 1982). At high temperatures, mortality was reported to be sporadic and the species poorly supports sharps changes in temperature but tolerate a high salinities (Payne, 1978).

It was reported that the status of reproduction and gamete management of *Tilapia quineensis* has a discontinuous reproductive cycle, regulated by cyclically active gonad tropes (Olaleye, 2005). The protein growth, synthesis and degradation in yolk-sac larvae of *Tilapia quineensis* have been measured and estimated to be over 100% protein growth (Conceicao *et al.*, 1997), protein synthesis retention efficiency as 69.6%, which makes the high growth rates of the fish possible through minimization of the costs of protein synthesis.

Many works have been reputed on the study sample such as the determination and bioaccumulation of some trace elements in *Tilapia quineensis* as pollution assessment (Annune *et al.*, 1994; Ipinmoroti & Oshodi, 1993; Odoemelam, 2005; Atolaye *et al.*, 2006; Aremu *et al.*, 2007a; Atolaye & Aremu, 2007b; Ayetuyo *et al.*, 2003), the effect of cooking on the contents of heavy metals in *Tilapia* species (Atta *et al.*, 1997); the growth production and control of *Tilapia quineensis* were also studied by Fagbenro (1987).

This work aims at investigating the nutritional qualities of *Tilapia quineensis* by determining proximate, mineral and amino acid composition as well as functional properties of the fish sample.

MATERIAL AND METHODS

Sample Collection and Treatment

Fresh sample of *Tilapia quineensis* was collected from a river site in Nasarawa town, Nasarawa State, Nigeria in March, 2007. The sample was brought into the laboratory, all bones and viscera removed, oven dried at about 60°C, cooled and blended into fine powder using Kenwood major blender. The powdered portion was put in a plastic container and kept in a refrigerator at about 4°C prior to use.

The sample was collected at 6.00h Green-Wich Mean Time (GMT) or 7.00 local time while temperature of the water was 28°C at the time of collection.

Proximate Analysis

The total ash, moisture, crude protein (N x 6.25), ether extract (crude fat) and fibre were determined in accordance with AOAC methods (AOAC, 1995. Both organic matter and carbohydrate were determined by difference. All the proximate analyses were carried out in triplicate and reported in percentages. All chemicals were of Analar grade.

Mineral Analysis

The minerals were analysed by dry-ashing the sample at 550°C to constant weight while dissolving the ash in volumetric flask using distilled, deionised water with a few drops of conc. nitric acid. Calcium (Ca), sodium (Na), potassium (K), magnesium (Mg), iron (Fe), zinc (Zn), manganese (Mn), copper (Cu), chromium (Cr) and lead (Pb) were determined by means of atomic absorption spectrophotometer (PYE Unicam Sp 9, Cambridege UK).

Amino Acid Analysis

The amino acid were quantitatively measured by the procedure of Spackman *et al.* (1958) using antomatic amino acid analyzer (Technicon TSM Sequential Multisample Analyzer). Sample was hydrolyzed for determination of all amino acids except tryptophan in consistent boiling hydrochloric acid for 22h under a nitrogen flush.

Estimation of Isoelectric Point (pI), Quality of Dietary Protein and Predicted Protein Efficiency Ratio (P - PER)

The predicted isoelectric point was evaluated according to Olaofe and Akintayo (2000)

$$pIm = \sum_{i=1}^{n=1} pI_i X_i$$

Where, pIm = The isoelectric point of the mixture of amino acids

pI_i = The isoelectric point of the i^{th} amino acids in the mixture

X_i = The mass or mole fraction of the i^{th} amino acids in the mixture

The quality of dietary protein was measured by finding the ratio of available amino acids in the protein concentrate compared with needs expressed as a ratio (FAO, 1970; Bender, 1992). Amino acid score (AMSS) was then estimated by applying the FAO/WHO (1991) formula;

$$AMSS = \frac{\text{mg of amino acid per g test protein}}{\text{mg of amino acid per g. ref. protein}} \times \frac{100}{1}$$

The predicted protein efficiency ratio (P - PER) of the fish sample was calculated from their amino acid composition based on the equation developed by Alsmeyer et al. (1974) as stated thus;

$$P - PER = - 0.468 + 0.454 (Leu) - 0.105 (Tyr).$$

Amino acid composition was classified and evaluated as Total Essential Amino Acids (TEAA) Essential Aliphatic Amino Acids (EAAA), Essential Aromatic Amino Acids (EArAA), Total Sulphur Amino Acids (TSAA) Total Acid Amino Acids (TAAA), Total Basic Amino Acids (TBAA) and Total Neutral Amino Acids (TNAA).

Functional Properties Determinations

Foaming Capacity (FC) and Foaming Stability (FS) were determined by the method described by Coffman and Garcia (1977). Full experimental details have been reported by Aremu *et al.* (2007b). Water and Oil Absorption Capacities (WAC & OAC) were measured by the Beuchat (1977) procedures. Oil Emulsion Capacity (OEC) was determined by the procedure of Beuchat (1977), as modified by Adeyeye et al. (1994) and Oil Emulsion Stability (OES) by the method of Beuchat (1977). Bulk Density (BD) was determined using the procedure of Chou and Morr (1979) as modified by Akpapunam & Markakis (1981); Narayana & Narasinga Rao (1984). Lowest Gelation Concentration (LGC) was determined by employing the method of Coffman and Garcia (1977) with slight modification as described by Aremu *et al.* (2007c).

RESULTS AND DISCUSSION

Proximate Composition

Table 1 presents the result of proximate composition of the fish sample. The ash content (8.2%) of *Tilapia quineensis* is considerably higher compared to the reported values of types of meat (1.3 - 1.8%) by Richard *et al.* (1971) however lower than the value reported for *Oreochromis niloticus* fish (25.33%) by Anta & Ogueji (2006). But comparable with the value of African catfish (Aremu & Ekunode, 2007d). The moisture content (12.5%) is high compared with values reported for some plant foods; rare cowpea (1.8%), cranberry bean (1.7%) and kersting's groundnut (1.7%) (Aremu *et al.*, 2006a); *Prosopis africana* (1.9%) (Aremu *et al.*, 2006b); fluted pumpkins (5.0 - 5.5%) (Ige *et al.*, 1984; Fagbemi & Oshodi, 1991; Olaofe *et al.*, 1994). The organic matter of 91.77% is higher than all the values reorted by Abdullahi and Abolude (2002) for four freshwater fishes of *Mormyrops deliciosus* (86.4%), *Bagrus bayad* (75.0%), *Synodontis budgetti* (84.0%) and *Hunichronis lasciatus* (76.0%). Both the protein content and metabolizable energy content of the *Tilapia quineensis* are comparable to their corresponding parameters in the four fish samples cited above. However, the present protein report of 56.9% is higher than those reported for the three local *Chana spp.* fish (19.9%, 22.1% and 23.0%) by Zuraini *et al.* (2006) and varieties of meat and fish samples; beef (18%), lamp (16%), pork (10%), haddock (17%), sardine (20%), markerel (17%) and oyster (11%) (Abdullahi and Abolude, 2002; Bhuiyan *et al.*, 1986; Brain and Allan, 1977). The result indicated that *Tilapia quineensis* is a good source of protein. The fat content in this report is higher than the value (5.21%) of *Gymnarchus niloticus* (Adeyeye & Adamu, 2005) and that of seafoods (Ogunlade *et al.*, 2005; Adeyeye & Adubiaro, 2004).

Table 1: Proximate composition (%) of *Tilapia quineensis* dry weight

Parameter	Concentration (%)[a]
Total ash	8.2±0.10
Organic matter	91.8±0.10
Moisture content	12.5±0.20
Crude protein	56.9±0.80
Crude fat	17.6±0.10
Crude fibre	ND
Available carbohydrate	4.8±0.50
Available energy (KJ)[b]	1699.4±5.5

[a]Values are mean ± standard deviation of triplicate determinations;
ND = Not detectable
[b]Calculated metabolisable energy (KJ/100g sample): (Protein x 17 + fat x 37 + carbohydrate x 17).

Table 2 shows the various energy values as contributed by protein, fat and carbohydrate. The daily energy requirement for an adult is between 2500 - 3000 Kcal (10455 - 12548KJ) depending on his physiological state while that of infants is 740Kcal (3094.68KJ) (Bingham, 1978; Adeyeye & Adamu, 2005). This implies that while an adult man would require between 6.56 - 7.88g of *Tilapia quineensis* to meet his minimum requirement; infants would require about 1.94g. The Utilizable Energy Due To Protein (UEDP%) for *Tilapia quineensis* (assuming 60% utilization) was 34.1. This value is far higher than the recommended safe level of 8% (Beaton and Swiss, 1974) for an adult man who requires about 55g protein per day with 60% utilization. This definetly shows that the protein concentration in *Tilapia quineensis* in terms of energy would be more than enough to prevent malnutrition in children and adult fed solely on *Tilapia quineensis* as a main source of protein (Adeyeye and Adamu, 2005).

Mineral Composition

Result of mineral content of Tilapia quineensis is shown in Table 2. Calcium was found to be the most abundant mineral in the fish sample. This value (172.34 mg/100g sample) agrees with the range values of fish spp (19 - 881mg/100g) reported by Murray and Burt (1969). Magnesium was found to be the next highest mineral component (11.92mg/100g). The body requires 800mg of Ca per day. Thus about 5g of Tilapia would have to be

Table 2: Energy values as contributed by protein, fat and carbohydrate in *Tilapia quineensis*

Parameter	Value
Total calculated energy	1699.4KJ
PEP	56.9
PEF	38.3
PEC	4.8
UEDP	34.1

PEP = Proportion of total energy due to protein;
PEF = Proportion of total energy due to fat;
PEC = Proportion of total energy due to carbohydrate;
UEDP = Utilizable energy due to protein.

consumed daily to meet body requirement since all would likely be absorbed by the body. Calcium behaves as a kind of coordinator among inorganic elements; if excessive amounts of K, Mg or Na are present in the body, Ca is capable of assuming a corrective role. If the amount of Ca is adequate in the diet, Fe is utilized to better advantage. This is an instance of sparing action (Fleck, 1976).

Magneguim is an important mineral element in connection with circulatory diseases, such as ischemic heart disease and calcium metabolism in bone (Ishida *et al.,* 2000). The high level of Mg in the sample may be as a result of its connection with calcium in the body, vital for the proper bone growth.

The value of Na in this report is higher than. This agrees excellently with the report of Adeyeye and Adamu (2005) on *Gymnarchus niloticus* with values of 78.44mg/ 100g and 54.25mg/100g, respectively. However the values of Na and K were too low far below the 2,500mg Recommended Daily Allowance (RDA) (NRC, 1989). The respective Na and K values of *Tilapia quineensis* to be consumed would be 1.02 and 2.87kg. These values might lead to dietary stress if depended upon as the sole source of Na and K. The higher level of Na than K is contrasted to what was observed in vegetable materials (Olaofe & Sanni, 1988; Aremu, *et al.,* 2005; Adeyeye & Fagbohun, 2005; Aremu *et al.*, 2006a), which is the reverse of the current report. The Fe, Cu and Zn wee low with respective values of 5.3mg/100g, 0.7mg/100g and 0.4mg/100g but they will still be available for biochemical functions. The daily Fe requirements by humans are 10 - 15mg for children, 18mg for women and 12mg for men. Cu requirement is 2mg daily. Fe and Cu are present in the enzyme cytochrome oxidase involved in energy metabolism (NAS, 1976). Both Na and K are required to maintain osmotic balance of body fluid and the pH of the body; regulate muscle and nerve mutability, control glucose absorption and enhance normal retention of protein during growth (NRC, 1989). The Na/K ratio less than one is recommended (Nieman *et al.,* 1992). Sodium to potassium ratio (1.6) in this report is greater than one, hence the fish sample may not have capacity to hinder high blood pressure. The Ca/Mg ratio is higher than the recommended value of 1.0 (NRC, 1989). The observed value for [K/(Ca + Mg)] was 0.008milliequivalent to prevent hypomagnesaemia, Marten and Andersen (1975) reported that the milliequivalent of [K/(Ca + Mg)] must be less than 2.2 hence, *Tilapia quineensis* may have capacity not to lead to hypomagnesaemia.

Table 3: Mineral composition of *Tilapia quineensis* on dry weight (mg/100g sample)

Mineral	Concentration (mg/100g)
Ca	172.34
Na	2.2
K	1.4
Mg	11.9
Fe	5.3
Zn	0.4
Mn	0.5
Cu	0.7
Cr	1.2
Pb	3.7
Na/K	1.6
Ca/Mg	14.5
[K/(Ca + Mg)	0.008meq*

*Milliequivalent

Table 3 also depicts the value for lead concentration (3.7mg/100g). Lead is toxic even at very low concentration and has no known function in biochemical processes. Sources of lead include storage batteries, agricultural chemicals, use of chemicals for fishing, type of metal and anti-knock compounds in petrol (Crossby, 1977; Obodo, 2002). The maximum permissible level of lead in the fish muscle by the US-FDA (Adeyeye, 1993) is 2.0ppm-wet weight. This implies that *Tilapia quineensis* cannot be said to be polluted.

Amino Acid Profile

Table 4 shows the result of amino acid composition in the sample of *Tilapia quineensis*. Lys was the most concentrated (7.2g/100g crude protein) essential amino acid in the sample while the most concentrated amino acids was Glu (13.8g/ 100g). Together, Glu and Asp made up 22.7g/100g protein. Phe with its sparing partner Tyr had concentration of 7.7g/100g. Arginine (5.9g/100g is an essential amino acid for children growth (Robinson, 1987) and it was high in the sample. Tryptophan was not determined. The calculated isoelectric point (pI) was 5.1. This is useful in predicting the pI for protein in order to enhance a quick precipitation of protein isolate from biological samples (Olaofe and Akintayo, 2000). The predicted protein efficiency ratio (P-PER) is one of the quality parameters used for protein

Table 4: Amino acid composition (g/100g crude protein) of *Tilapia quineensis* on dry weight

Amino acid	*Tilapia quineen.*
Lysine (Lys) [a]	7.2
Histidine (His) [a]	2.8
Arginine (Arg) [a]	5.9
Aspartic acid (Asp)	8.9
Threomine (Thr) [a]	3.9
Serine (Ser)	3.4
Glutamic acid (Glu)	13.8
Praline (Pro)	4.2
Glycine (Gly)	5.8
Alanine (Ala)	6.1
Cystine (Cys)	0.7
Valine (Val) [a]	4.6
Methionine (Met) [a]	2.5
Isoleucine (Ile) [a]	4.2
Leucine (Leu) [a]	6.5
Tyrosine (Tyr)	3.5
Phyenylalanine (Phe) [a]	4.2
Isoelectric point (pI)	5.1
P – PER	2.12

[a]Essential amino acid; *Calculated isoelectric point;
P – PER = Predicted protein efficiency ration.

evaluation (FAO/WHO, 1991). The P-PER in this report (2.12) is higher than the reported P-PER values of some legume flours/concentrates; *Phaseolus coccineus* (1.91) (Aremu *et al.*, 2007c), *Prosopis africana* (2.3) (Aremu *et al.*, 2007e), Lathyrus sativus (1.03) (Salunkhe & Kadam, 1989). However, it can be said that the fish sample under investigation satisfied the FAO requirements (FAO/WHO/UNU, 1985). The evaluation report on amino acid based on classification is shown in Table 5. The total amino acids, TAA (88.3g/100g crude protein) in the report is far higher than reported values in plant foods which range between 39.3 - 76.5g/100g (Olaofe *et al.*, 1994; Akobundu *et al.*, 1982; Aremu *et al.*, 2006b; Aisegbu, 1987; Adeyeye, 1997a,b); also higher than TAA value of *Gymnarchus niloticus* fish (64.76g/100g). The Total Sulphur Amino Acid (TSAA) was 3.2g/100g which is lower than the 5.8g/100g recommended for infants (FAO/WHO/UNU, 1985). The Essential Aromatic Amino Acid (EArAA) of *Tilapia quineensis* (4.2g/100g) is lower than the range suggested for ideal infant protein (6.8 - 11.8g/100g) (FAO/WHO/UNU, 1985). Table 5 also depicts the TAAA which was found to be greater than the (TBAA) indicating that the protein is probably acidic in nature (Aremu *et al.*, 2006d). The percentage (TAA) of *Tilapia quineensis* in this report is comparable to that of egg (50%) (FAO/WHO, 1991); *Vigna subterranean* concentrate (49.76%) (Aremu *et al.*, 2007c) and beach pea protein isolate (44.4%) (Chavan *et al.*, 2001).

Table 5: Essential non-essential, acidic, basic, neutral and aromatic (g/100g crude protein) of *Tilapia quineensis* on dry weight

Classification	Concentration
Total Amino Acids (TAA)	88.3
Total Essential Amino Acids (TEAA)	
with Histidine	41.9
without Histidine	39.1
% TEAA	
with Histidine	47.5
without Histidine	44.3
Total Non-Essential Amino Acids (TNEAA)	
% TNEAA	46.5
Essential Alphatic Amino Acids (EAAA)	52.7
% EAAA	19.2
Essential Aromatic Amino Acids (EArAA)	4.2
% EArAA	4.8
Total Acidic Amino Acids (TAAA)	22.7
% TAAA	25.7
Total Basic Amino Acids (TBAA)	16.0
% TBAA	18.1
Total Sulphur Amino Acids (TSAA)	3.2
% TSAA	3.6
% Cystine in TSAA	21.9

Table 6: Amino acid scores of *Tilapia quineensis*

Amino Acid	PAAESPa	EAAC	AMS
Ile	4.0	4.2	1.05
Leu	7.0	6.5	0.93
Lys	5.5	7.2	1.31
Met + Cys (TSAA)	3.5	3.2	0.91
Phe + Tyr	6.0	7.7	1.28
Thr	4.0	3.9	1.00
Try	1.0	nd	na
Val	5.0	4.6	0.92
Total	36.0	37.3	7.4

[a]Source: Belschant *et al.* (1975) PAAESP = Provisional Amino Acid (Egg) Scoring Pattern; EAAC = Essential Amino Acid Composition (see Table 4); AMS = Amino Acid Scores; nd = not determined; na = not available.

The amino acid scoring table (Table 6) shows that the first limiting amino acid in *Tilapia quineensis* fish sample was Met + Cys (TSAA) with value of 0.91 followed by Val as second limiting amino acid. When comparing the essential amino acids in this report with the recommended FAO/WHO provisional pattern, the fish sample was superior with respect to Ile, Lys, and Phe + Tyr while it was adequate in Thr but supplementation may be required in Leu, Met + Cys (TSAA) and Val.

Functional Properties

Some functional properties of *Tilapia quineensis* are presented in Table 7. Both foaming capacity (3.9%) and foaming stability (2.6%, 8h) were very low. Foaming capacity in this report is lower than FC in most vegetables protein and some animals protein; benni seed (18.0%), pear millet and quinoa (19.0%) reported by Oshodi et al. (1999), selected sea foods (6-14%) (Ogunlade *et al.,* 2005), varieties of legume seeds (7.9-15.5%) (Aremu *et al.,* 2007b), soybean (66%) (Lin *et al.*, 1974), great Northern bean (32%) (Sathe *et al.*, 1982), varieties of African yam bean (54.0-55.0%) (Oshodi *et al.,* 1997). Consequently, Tilapia quineensis would not be attractive for products like cakes or whipping toppings where foaming is important (Kinsela, 1979). The water absorption capacity (WAC) value 220% of Tilapia quineensis is comparable with that of soya flour (130%); sun flower flour (107%) (Lin *et al.,* 1974); various liman bean (130-142%) (Oshodi & Ekperigun, 1989) and *Zonecerus variegates* (127.5%) (Olaofe *et al.,* 1998) so the fish sample could be a useful replacement in viscous food formulations such as soups or baked goods. The oil absorption capacity (OAC) was also high (230.3%). The value is higher than *Zonecerus variegatus* (33.3%) (Olaofe *et al.,* 1998), pigeon pea flour (89.7%) (Oshodi & Ekperigun, 1989), wheat (84.2%) and soya flour (84.4%) (Lin *et al.,* 1974). OAC is important as oil acts as a flavour retainer and improves the mouth feel of foods (Kinsella, 1976). So *Tilapia quineensis* would be a good sample for this property better than most of the materials cited.

Table 7: Some functional properties of *Tilapia quineensis*

Parameter	^{a}Value
Foaming Capacity (FC) %	3.9±0.3
Foaming Stability (FS) at 8h %	2.6±0.1
Water Absorption Capacity (WAC) %	220.1±5.1
Oil Absorption Capacity (OAC) %	230.3±3.5
Oil Emulsion Capacity (OEC) mlg^{-1}	55.0±0.4
Oil Emulsion Stability (OES) at 12h mlg^{-1}	46.0±2.0
Lowest Gelation Concentration (LGC) %	410±3.0
Bulk Density (BD) (gL^{-1})	8.0±0.00

^{a}Values are mean ± standard deviation of triplicate determinations.

The fish sample in the present study had a high value of OEC (55mlg^{-1}) in comparison with the values reported for soybean (18%) (Lin *et al.*, 1974) and pigeon peas (7.11%) (Oshodi & Ekperigun, 1989). This indicates that *Tilapia quineensis* might be useful in the production of sausages, soups and cakes (Kinsella, 1976). The OES value was 46mlg^{-1}, being the volume of water separated after 12h. the least gelation concentration value (8%) is lower than the values reported for some legumes; lupin seed (14%) (Sathe *et al.*, 1982); Vigna subterranean, *Kerstingiella geocarpa* and *Vigna unguiculata* (14,14 and 16%, respectively) (Aremu *et al.*, 2007b) *Tilapia quineensis* may therefore provide good consistency to food body and be used in cheese and curd making (Altschul and Wilcke, 1985). The bulk density value (410g L^{-1}) is higher the values reported for various samples of extrusion texturized soya products with varied protein and soluble sugar contents (238.2-446.0g L^{-1}) (Cherry, 1981) and various processed defatted fluted pumpkin seed flours (180-380 g L^{-1}) Fagbemi *et al.*, 2006)

CONCLUSION

The results revealed that the fish sample is good sources of energy, protein (amino acids) and essential minerals. It was also observed that the foaming capacity and stability in the fish samples were higher than some legume flours. Since foam contributes to smoothness, lightness, flavour, dispersions and palatability, hence the results obtained from the present study indicate that the sample could serve as potential replacement of known proteins in food applications requiring high foam ability and stability, for example, cakes, breads, marshmallows, whippings, tippings, ice creams and desserts. The sample also possesses high water and oil absorption capacities. They could therefore be potentially useful in flavour retention improvements of palatability and extension of shelf life in meat products. The high emulsion activity and stability of the fish sample which compare favourably with legume flour/concentrate indicate that Tilapia quineensis could be used as ingredients in many food formulations such as salad dressing, communized meat and ice creams, cake buffers and mayonnaise.

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