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Growth performance of the Nile Tilapia (*Oreochromis Niloticus*) fed raw and processed roselle (*Hibiscus Sabdariffa*) Seed Based Diets

[1]Yunusa, A., [1]Buba, W.,[2]Onimisi, M. M., [1]Onimisi, H. U. and [2]Yusuf, A.

[1]National Agricultural Extension and Research Liaison Services, (NAERLS) Ahmadu Bello University, Zaria – Nigeria

[2]Department of Fisheries and Aquaculture Kogi State University

Corresponding author: *ayunusa153@yahoo.com* , *08174448883*

Abstract

Tilapia (Oreochromis niloticus) is one of the most important fish species in aquaculture, as it is widely cultivated and consumed around the world. Roselle seed can be a viable alternative feed ingredient for tilapia. However, research is needed to optimize the different processing methods and nutrient composition of Roselle seed-based diets to ensure maximum growth and performance of tilapia. This study was carried out to investigate the growth performance of the Nile Tilapia (Oreochromis niloticus) fed with raw and differently processed Hibiscus sabdariffa (Roselle) as a protein source. Fifteen plastic aquaria of 60cm x 50cm x 30cm were used to rear tilapia for 28 weeks. Each aquarium was stocked with twenty fingerlings (average weight 0.60g), continuous aeration was provided using a whirl charging electro-magnetic aerator (Model: ACO 003). Water quality parameters were carefully monitored. The results for the proximate composition (PC) of Raw and Processed Roselle seeds indicated that the crude protein (CP) level was higher in Fermented Roselle [FR] (39.70%); followed by Boiled Roselle [BR] (38.82%), Soaked Roselle [SR] (38.50%), Raw Roselle [RR] (38.02%) and the least CP level was found in Sprouted Roselle [SPR] (37.70). All these values were significantly different ($p<0.05$). The results obtained for the growth performances indices (GPI) were statistically different ($p<0.05$). O. niloticus fed FR had the highest mean weight gain of 369.11g, followed by the fish fed with BR (359.64); SPR (358.74), SR (349.68) and RR (349.18). Other growth parameters indicated similar trend. Specific Growth Rate values obtained were RR (0.26) SR (0.28) BR (0.29) SPR (0.28) and FR (0.30). In conclusion all the various processing techniques employed in this study had significant effects on the PC and GPI of O, niloticus while FR was the best of all.

Key words: Substitution, Fish meal, Processed Roselle seed, growth, Tilapia

Performances de croissance du tilapia du Nil (*Oreochromis niloticus*) nourri avec de la crue et transformée Roselle (*Hibiscus Sabdariffa*)

Résumé

Le tilapia (Oreochromis niloticus) est l'une des espèces de poissons les plus importantes en aquaculture, car il est largement cultivé et consommé dans le monde entier. La graine de Roselle peut être un ingrédient alimentaire alternatif viable pour le tilapia. Cependant, des recherches sont nécessaires pour optimiser les différentes méthodes de traitement et la composition en nutriments des régimes à base de graines de Roselle afin d'assurer une croissance et des performances maximales du tilapia. Cette étude a été réalisée pour étudier les performances de croissance du tilapia du Nil (Oreochromis niloticus) nourri avec Hibiscus sabdariffa (Roselle) brut et traité différemment comme source de protéines. Quinze aquariums en plastique de 60 cm x 50 cm x 30 cm ont été utilisés pour élever des tilapias pendant 28 semaines. Chaque aquarium a été rempli de vingt alevins (poids moyen 0,60 g), une aération continue a été assurée à l'aide

d'un aérateur électro-magnétique à charge tourbillonnaire (Modèle : ACO 003). Les paramètres de qualité de l'eau ont été soigneusement surveillés. Les résultats pour la composition approximative (CA) des graines de Roselle brutes et transformées ont indiqué que le niveau de protéines brutes (PB) était plus élevé dans la Roselle fermentée [RF] (39,70 %) ; suivi de Roselle Bouillie [RB] (38,82 %), de Roselle Trempée [RT] (38,50 %), de Roselle Crue [RC] (38,02 %) et le niveau de CA le plus bas a été trouvé dans Roselle Germée [RG] (37,70). Toutes ces valeurs étaient significativement différentes (p<0,05). Les résultats obtenus pour les indices de performances de croissance (IPC) sont statistiquement différents (p<0,05). O. niloticus nourri avec RF avait le gain de poids moyen le plus élevé de 369,11 g, suivi par les poissons nourris avec RB (359,64); RG (358,74), RT (349,68) et RC (349,18). D'autres paramètres de croissance ont indiqué une tendance similaire. Les valeurs de taux de croissance spécifiques obtenues étaient RC (0,26) RT (0,28) RB (0,29) RG (0,28) et FR (0,30). En conclusion, toutes les différentes techniques de traitement employées dans cette étude ont eu des effets significatifs sur le CA et le IPC de O, niloticus tandis que RF était le meilleur de tous.

Mots-clés : Substitution, Farine de poisson, Graine de Roselle transformée, Croissance, Tilapia

Introduction

Aquaculture is a rapidly growing industry that has been established as an important source of animal protein for human consumption (FAO, 2021). Tilapia (*Oreochromis niloticus*) is one of the most important fish species in aquaculture, as it is widely cultivated and consumed around the world (El-Sayed, 2006). However, the cost of commercial feed can be a significant barrier to the growth and profitability of tilapia farming (Lovell, 1989).

As a result, researchers have been exploring alternative sources of feed for tilapia, including plant-based ingredients such as Roselle seed (*Hibiscus sabdariffa*). Roselle is a plant that is widely grown in tropical and subtropical regions, and its seeds have been used in traditional medicine and as a food ingredient in many cultures (Gupta *et al.,* 2018). Studies have shown that Roselle seed has potential as a source of protein, fat, and other nutrients for tilapia (Chou *et al.,* 2015; Nguela *et al.,* 2018; Zhou *et al.,* 2020), which could reduce the cost of feed and improve the sustainability of tilapia farming.

Several studies have investigated the growth performance of Nile tilapia fed raw and processed Roselle seed-based diets. Chou et al. (2015) found that both raw and processed Roselle seed-based diets were able to support growth and development in Nile tilapia, with no significant differences observed between the two diets. Nguela et al. (2018) found that Nile tilapia fed a diet containing up to 30% Roselle seed meal had similar growth rates, feed conversion ratios, and survival rates compared to a control group fed a commercial diet. Similarly, Zhou et al. (2020) found that Nile tilapia fed a diet containing up to 30% Roselle seed meal had similar growth rates and feed conversion ratios compared to a control group fed a commercial diet. These studies suggest that Roselle seed can be a viable alternative feed ingredient for tilapia.

However, further research is needed to optimize the different processing methods and nutrient composition of Roselle seed-based diets to ensure maximum growth and performance of tilapia. The objectives of this study were to evaluate the effects of feeding raw and differently processed Roselle seed-based diets on the growth performance of Nile tilapia.

MATERIALS AND METHODS.

Study Area

The Study was conducted at the Aquaculture Unit, Skill Acquisition and Entrepreneur Development Centre, National Agricultural Extension and Research Liaison Services, Ahmadu Bello University, Zaria. The area is located within the Northern Guinea Savannah Zone of Nigeria at latitude 11° 09' 06'' N and longitude 7° 38' 55'' E, at an altitude of 706m above sea level (GPS, 2022)

Purchase of feedstuff

Groundnut cake, maize soybean cake and bone meal were purchased from a reputable feed miller in Zaria. Palm oil, common salt, maize bran and wheat offal were purchased from Samaru Market, Zaria. Imported fish meal, vitamin and mineral premix were purchased from an agro- based shop in Zaria. *Hibiscus sabdariffa* seeds were purchased from Sabon-Gari Market, Zaria.

Processing of feedstuff

Two and half kilogram (2.5kg) of raw Roselle seeds were thoroughly cleansed and milled to be incorporated in the diets of *O. niloticus*. Another 2.5kg of the seeds was boiled for 30 minutes at 100°C, the boiled Roselle seeds were later sun-dried for 3 days and milled into powder using hammer mill. A third 2.5kg Roselle seeds were boiled for 30 minutes at 100°C washed and kept in an air tight container to ferment for three days. The fermented seeds were sun-dried for 3 days, then milled and incorporated into the experimental diet. Lastly, the fourth 2.5kg of seeds were cleansed, washed and soaked in water for 24 hours and kept in sack for three days to sprout. The sprouted Roselle were dried for 72 hours thereafter ground into powder and incorporated into the diets of *Oreochromis niloticus*. The four types of differently processed Roselle seeds which are prepared was mixed with other feed ingredients to formulate feed. The feed was pelleted using a locally fabricated industrial pellet. The experimental diets were thereafter taken to the laboratory and analysed for proximate composition according to AOAC (2002). The ingredient compositions of the feedstuff used in the experimental diets were indicated in Table 1.

Proximate Analysis

The proximate composition of the raw and processed Roselle seed meals was analysed. The dry matter, moisture content, Ash content, crude protein, crude lipid, crude fibre, Nitrogen free extracts and total carbohydrates were determined by AOAC (1990) method.

Determination of Growth and Nutrient Utilization Parameters

(i) Mean body weight gain

(MWG) = W_2-W_1

Where W_1= initial body weight

W_2= Final body weight

Table 1: Composition of the experimental Diets

Ingredients (g/100g)	RRSM	FRSM	BRSM	SP. RSM	SRSM
Fish meal	26.0	26.0	26.0	26.0	26.0
H.sabdariffa	26.0	26.0	26.0	26.0	26.0
Wheat offal	20.0	20.0	20.0	20.0	20.0
Maize	20.0	20.0	20.0	20.0	20.0
Vit./min. Premix*	1.0	1.0	1.0	1.0	1.0
L-ysine	0.2	0.2	0.2	0.2	0.2
DL-Methionine	0.2	0.2	0.2	0.2	0.2
Palm Oil	0.8	0.8	0.8	0.8	0.8
Dicalcium phosphate	0.2	0.2	0.2	0.2	0.2
Common salt	0.5	0.5	0.5	0.5	0.5
Groundnut cake	5.0	5.0	5.0	5.0	5.0
AIA	0.1	0.1	0.1	0.1	0.1

RRSM – Raw roselle seed meal; FRSM – Fermented roselle seed meal; BRSM – Boiled roselle seed meal; SP.RSM – Sprouted roselle seed meal; SRSM – Soaked roselle seed meal

(ii) **Specific Growth Rate** (Kaushik, 1998)
(SGR) = 100(Ln W_2- Ln W_1)/ T
Where W_1= initial body weight
W_2= Final body weight
Ln= Natural log
T = Time

(iii) **Feed conversion Ratio** (Adikwu, 2011)
(FCR)= weight of feed fed/ weight gain by fish x 100

(iv) Protein Efficiency Ratio
(PER)= weight gain/weight of protein consumed

(v) **Apparent Net protein utilization [ANPU] (g)** (AOAC,2000)
ANPU = fish protein gained (g) /protein consumed (g) X100

(vi) **Daily Rate of Growth (DRG)** was calculated according to formula:

$$\mathbf{DRG} = \frac{\text{Mean increase in weight per day}}{\text{Body weight of Fish}}$$

(vii) Gross Feed Conversion Efficiency: The gross food conversion efficiency was calculated according to the method of Stickney (1979) as a percentage of the reciprocal of conversion ratio

(viii) Protein Intake (PI): Protein intake was calculated according to Lovell (1989) formula
PI = Feed intake (g) x % protein in the diet

(ix) Nitrogen Metabolism (NM): This was calculated using the method of Steer *et al*. (2003) as: -$\mathbf{NM} = \frac{(0.54)(b-a)h}{2}$
Where a = initial weight of fish
b = final weight of fish
0.54 = Experimental constant
h = Experimental periods in days

(x) Survival Rate (SR) %

$$\mathbf{SR} = \frac{\text{Total number of fish harvested}}{\text{Initial number of fish stocked}} \times 100$$

Data Analysis
Data were analysed using SPSS Statistical Package (Version 15.0, SPSS Inc. Chicago, IL). Differences among dietary treatment means were tested by analysis of variance (ANOVA), and means compared using Turkey's Multiple Comparison Test (Steele and Torrie, 1960).

Results and Discussion

Proximate Composition of Raw and Processed Roselle
Results for the proximate composition of Raw and Processed Roselle indicated that the crude protein level was higher in Fermented Roselle (39.70%). Followed by Boiled Roselle (38.82%), Soaked Roselle (38.50%) Raw Roselle (38.02%) and the least crude protein level was found in Sprouted Roselle (Table 2). Conversely, crude fibre and crude lipid were higher in sprouted Roselle. The next level of crude fibre was found in Soaked Roselle (15.40%), followed by Fermented Roselle (15.05%), then Boiled Roselle (14.94%) and lastly Raw Roselle (13.30%). Soaked Roselle had the second higher value for crude lipid (20.53%), the next was Boiled Roselle (20.27%), then Raw Roselle (19.80%) and lastly Fermented Roselle (18.92%). Ash content was highest in Raw Roselle (5.03%), followed by Sprouted Roselle (4.53), then Soaked Roselle (4.51), and Boiled Roselle (4.42%) and lastly Fermented Roselle (4.39%). NFE was highest in Soaked Roselle (21.55%) followed by Raw Roselle (21.10%) and then Fermented Roselle (21.03%) and Sprouted Roselle (20.45) and lastly the Boiled Roselle (19.68%). This higher quantity of proximate composition during fermentation might be associated with microbial and biochemical activities. An increase in most of the nutrients in the fermented Roselle seeds might be the effect of the fermentation process that leads to nutritional improvement.

Table 2. Proximate Percentage Composition of Raw and Processed Roselle Seeds.

Constituents	Sorrel seed processing methods				
	RR	SR	BR	SP. R	FR
Crude protein	38.82±0.07^{b}	38.50±0.07^{c}	38.82±0.07^{b}	37.70±0.07^{d}	39.70±0.07^{a}
Crude Fibre	13.30±0.03^{e}	15.40±0.03^{b}	14.94±0.03^{d}	15.60±0.03^{a}	15.05±0.03^{c}
Crude Lipid	19.80±0.03^{d}	20.53±0.03^{b}	20.27±0.03^{c}	20.98±0.03^{a}	18.92±0.03^{e}
Ash	5.03±0.00^{a}	4.51±0.00^{c}	4.42±0.00^{d}	4.53±0.00^{b}	4.39±0.00^{e}
Nitrogen free extract	21.10±0.01^{b}	21.55±0.00^{a}	19.68±0.01^{e}	20.45±0.01^{d}	21.03±0.01^{c}

Means on the same row with the same superscripts are not significantly different ($p<0.05$)
RR—Raw Roselle; SR—Soaked Roselle; BR—Boiled Roselle; SP. R—Sprouted Roselle; FR—Fermented Roselle; NFE—Nitrogen Free Extract

This agrees with the findings of Ibrahim (2011), Ari *et al.* (2014) and Yigzaw *et al.* (2014). The crude protein contents of the fermented Roselle seed (39.70%) is higher than 37% reported for soybean (NRC 1997; Smith *et al.,* 2001). It is also higher than rape seed (36%), palm kernel (35%), mustard (32%), and sunflower (20%) as reported by Ari *et al*. (2012). This high quality of protein of fermented *H.sabdariffa* seeds can serve as a good source of protein in fish diet. Roselle also had higher values of all the essential amino acids than those reported in soybean (NRC, 1994). In this study Roselle had a reasonable content of oil to satisfy the calorie demand of the fish populations.

The reason for the higher fibre content in the processed seeds is probably due to the loss of some soluble nutrients in the processing water as all the methods involved moistening. Crude protein, crude lipid and crude fibre significantly increased (P<0.05%) while Ash, carbohydrates were decreased. The changes observed are due to leaching of soluble components into soaking and boiling and as a consequence of enzyme activities during sprouting. Obizoba and Atii, 1992; Saikia *et al.,* 1999; Yagoub and Abdallah, 2007, observed and reported a similar trend.

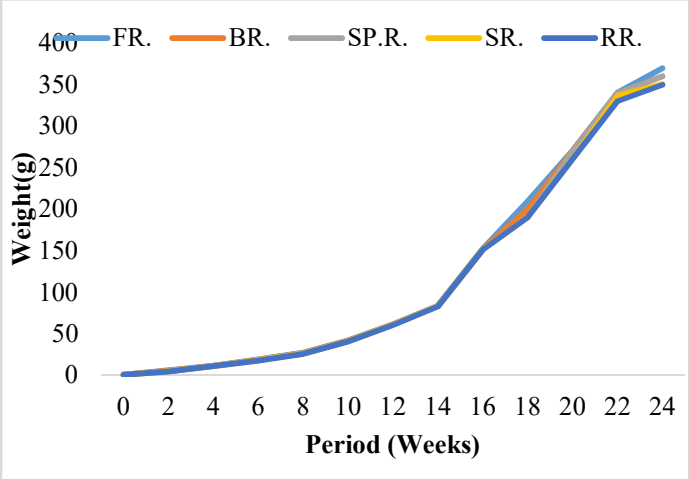

Figure I: Biweekly growth of *O.niloticus* fed processed Roselle seed meals.
FR---Fermented Roselle; BR---Boiled Roselle; SP. R-Sprouted Roselle; SR---Soaked Roselle; RR---Raw Roselle

The result for the growth performance and nutrient utilization is showed in Table 3. The results revealed that *O. niloticus* fed fermented Roselle seed meal were superior to the fish fed raw and other methods of processing. They had the mean weight gain of 369.11g, followed by boiled Roselle (359.64) then sprouted Roselle (358.74), soaked Roselle (349.68) and lastly the raw Roselle (349.18). Other growth parameters followed the same pattern as the mean weight gain. The Daily Rate of Growth (DRG) values were 12.82, 12.00, 13.00, 12.40 and 13.50 for raw, soaked, boiled sprouted and fermented Roselle. Specific Growth Rate (SGR) values obtained were: raw (0.26) soaked (0.28) boiled

(0.29) sprouted (0.28) and fermented Roselle (0.30). Feed Conversion Ratio (FCR) of 2.00, 1.98, 1.70, 1.90 and 1.5 were obtained for raw, soaked, boiled sprouted and fermented Roselle respectively. The gross food conversion efficiency (GFCE) obtained for raw, soaked, boiled, sprouted and fermented Roselle were 50.00, 50.51, 58.82, 52.63, and 66.67 respectively. Productive Protein Value (PPV) values of 75.55, 79.01, 84.35, 80.00 and 89.00 were obtained for raw, soaked, boiled, sprouted and fermented Roselle respectively. The survival rate for all the treatments was 100%.

A qualitative comparison of the processing techniques showed nutritional superiority of fermented Roselle seeds on the other methods. This was due to the fermentation process which is recognized as converter of food compound into structurally related but financially more viable food through the activities of microbial cells (Ari *et al*. 2012). This finding is supported by various reports on the effect of different fermentation methods on the health and growth responses of broiler chickens (Ari and Ayanwale, 2012). The synergistic effect of beneficial fermentation microbes and host micro-organisms must have led to reduction in the content of pathogenic bacteria and increased the population of useful micro flora in gut, resulting to improvement in the gastrointestinal health and performance of broilers as reported by Yagoub *et al.* (2008) and Ari *et al*. (2012). Other factors that may be responsible could be the positive effects of fermentation originating from enzymes of the seed itself. Other performance indicators of the Nile tilapia *(Oreochromis niloticus*) observed in this study suggested that fermentation as a processing method also gave the best Feed conversion ratio (FCR), Protein intake (PI), and Nitrogen metabolism (NM), Adikwu (2011), reported that the lower the FCR the better the feed utilization by the fish. This result supports the observation made by Shabbir (2003) and Jabean *et al*. (2004) in a related study. Also, the PER and FCR values recorded in this study were within the range reported by Mugendi *et al*. (2010) in their works on the effect of processing techniques on the nutritional composition and anti-nutrients contents of Mucuna beans (*Mucuna pruriens* L.) In the same work, the researchers reported the best values for body weight gain, FCR, and survival percentage in both the starter and finisher phase for broilers in fermented Mucuna beans. (Mugendi *et al*. 2010). The next processing technique after fermentation that equally produced good growth in this study was boiling. This agrees with the findings of Duwa *et al*. (2012) in their work on the effect of processing methods on the utilization of sorrel (Roselle) seed meal by broilers. They also added that the feed cost per Kg gain showed significant difference in favour birds fed on boiled sorrel seed meal among the types of different processing methods in the three phases of study.

Conclusion

In conclusion the various processing techniques employed in this study had significant effect on the proximate composition of *H. sabdariffa* seed meals. Fermentation of the seeds gave the best nutritional qualities. The results indicate that Roselle seed can be a suitable alternative source of protein in Nile tilapia diets without compromising growth performance or body composition. Fermented Roselle seed in tilapia diets could also offer economic benefits to fish farmers. Further research on the optimal inclusion rate of Roselle seed in tilapia diets is recommended to fully exploit the potential of this feed ingredient. Overall, the findings of this study contribute to the growing body of knowledge on sustainable and cost-effective aquaculture practices that can support the global demand for fish as a crucial source of protein.

Table 3: Growth Performance and Nutrient Utilization of *O. niloticus* fed Raw and Processed Roselle Seed Meals.

Growth parameters	TREATMENTS				
	RR	**SR**	**BR**	**S.PR**	**FR**
Initial weight of fish (g)	0.60	0.60	0.60	0.60	0.60
Final weight of fish(g)	349.78^{c}	$350,28^{d}$	360.24^{b}	359.34^{c}	369.71^{a}
Mean weight gain (g)	349.18^{e}	349.68^{d}	359.64^{b}	358.74^{c}	369.11^{a}
Daily rate of growth (g)	12.82^{c}	12.00^{e}	13.00^{b}	12.40^{d}	13.50^{a}
Specific growth rate (g)	0.26^{d}	0.28^{c}	0.29^{b}	0.28^{c}	0.30^{a}
Feed conversion ratio	2.00^{a}	1.98^{b}	1.70^{d}	1.90^{c}	1.50^{e}
Gross Feed Conversion efficiency (%)	50.00^{d}	50.51^{d}	58.82^{b}	52.63^{c}	66.67^{a}
Apparent Net Protein utilization	75.55^{b}	79.01^{c}	84.35^{b}	80.00^{c}	89.02^{a}
Survival rate (%)	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}

Means on the same row with the same superscripts are not significantly different ($p<0.05$)

References

Adikwu, (2011). Dietary carbohydrate utilization in Tilapia *Oreochromis niloticus. Journal Agricultural Science Technology*. **2**(1): 33 – 37.

AOAC (1990). Association of Official Analytical Chemist. Official methods of analysis, 14th ed. S. William (ed) Arlington, V.A. 1102 pp.

AOAC (2000). Official method of Analysis of AOAC 17th Edition. Association of Official Analytical Communities, Arlington, VA, USA.

AOAC (2002). Methods of analysis of the association of analytical chemist. Association of Analytical Chemist Inc. Arlington.

Ari, M. M., Ayanwale, B. A., Adama, T. Z. and Olatunji, E. A (2014). Effects of different Fermentation methods on the Proximate Composition, Amino acid profile and some Anti-nutritional Factors (ANFs). In soybeans (*Glycine max) Fermentation Technology and engineering* 2:6-13.

Ari, M. M. and B. A. Ayanwale (2012). Nutrient retention and serum profile of broilers fed fermented African locust beans (*Parkia filicoide). Asian Journal Agricultural Research*, 6: 129-136.

Chou, Y. C., Cheng, W., & Chen, H. Y. (2015). Growth performance and body composition of Nile tilapia (*Oreochromis niloticus*) fed raw and processed Roselle (*Hibiscus sabdariffa*) seed-based diets. *Journal of Aquaculture Research and Development,* 6(7), 1-6.

Duwa, H., Oyawoye, E. o. and Njidda, A. A. (2012). Effect of processing methods on the utilization of Sorrel Seed meal by Broilers *Pakistan Journal of Nutrition* 11(1) 38-46.

El-Sayed, A. F. M. (2006). Tilapia culture. CABI Publishing**.**

Food and Agriculture Organization of the United Nations (FAO). (2021). The State of World Fisheries and Aquaculture 2021. Rome.

Gupta, A., Mahajan, M., & Kaur, N. (2018). Roselle (*Hibiscus sabdariffa L*.) seeds as a source of food and feed: A review. Journal of Food Science and Technology, 55(8), 2900-2907.

Ibrahim, N. A (2011). Effect of phytoplankton *Chlorella vulgaris* and Scenedesmus spp Inoculation on water quality for Tilapia culture by Urea and Superphosphate. Ph.D.

Jabeen, S., Salim, M. and Akhtar, P (2004). Study on feed conversion ratio of major carp (*Cirrhinus mrigala)* fingerlings fed on cotton seed meal, fish meal and barley. *Pakistan Veterinary Journal*, 24(1): 42-46.

Kaushik, S. J. (1998). Nutritional bioenergetics and estimation of waste production in non-salmonids. *Aquatic Living Resources,* 11, 211-217.

Lovell, T. (1989). Nutrition and feeding of fish. Van Nostrand Reinhold.

Mugendi, J. B., Njagi, E. N. M., Kuria, E. N., Mwasaru, M. A., Mureithi, J. G. and Apostolides, Z (2010). Effects of processing technique on the nutritional composition and anti-nutrient content of Mucuna bean (*Mucuna pruriens* L.). *African Journal of Food Science,* 4(4):156-166.

Nguela, R. L., Magembe, J. A., Nahayo, L.,and Hishamunda, N. (2018). Growth performance and economic feasibility of Roselle (*Hibiscus sabdariffa*) seed meal as a dietary protein source in Nile tilapia (*Oreochromis niloticus*) feeds. Aquaculture International, 26(1), 95-107.

N.R.C (1994). Nutrients requirement of poultry 9th Revised Edition. National Academy Press, Washington, DC. USA.

NRC, (1997). National Research Council. Nutrient Requirements of Swine, 10th Ed. National Academy of Science, Washington, DC, 189 pp.

Obizoba, I.C. and J.V. Atii. (1992). Effect of soaking, sprouting, fermentation and cooking on nutrient composition and some anti-

nutritional factors of sorghum (Guinesia) seeds. *Plant Foods Human Nutrition*, 41: 203-212.

Saikai, p., Sarkar, C. R. and Borua, I (1999). Chemical composition, anti-nutritional factors and effects of cooking and nutritional quality of rice bean (*Vigna umbellate) Food Chemistry* 67:347-352.

Shabbir, S. Salim, M. Rashid, M (2003). Study on the feed conversion ratio (FCR) in major carp (*Cirrhinus mrigala*) fed on sunflower meal, wheat bran and maize gluten (30%). *Pakistan Veterinary Journal*, 23(1): 1-3.

Smith, A. J. (2001). Poultry: The Tropical Agriculture Revised Edition, published by Macmillan Education LTD. London and Oxford UK 218pp.

Steele, R. G. D. and Torrie, J. H (1960). Principles and procedures of statistics. New York: McGraw-Hill, NY, 481 pp.

Steer, T. E., Johnson, I. t., Gee, J. M. and Gibson, E. R. (2003). Metabolism of the Soybean Isoflavone Glycocide Gliciston *in-vitro.* Human Gut bacteria and the effect of probiotics Vol. 90 (3) 635-643.

Stickney R.R. (1979). Principles of Warm water Aquaculture. New York, USA: Wiley-Inter science.thesis. Faculty of Agriculture, Cairo University. Egypt.

Yagoub A. G., Mohammed. M. A and Baker, A. A. A (2008). Effect of working sprouting and cooking chemical composition. Bioavailability of mineral and in *vitro* protein digestibility of Roselle (*Hibiscus sabdariffa L.*) seed. *Pakistan Journal of Nutrition* 7(1) 50-56.

Yagoub, A. A., Abdalla, A. A. (2007). Effect of domestic processing methods on chemical, in vitro digestibility of protein and starch and functional properties of Bambara nut (*Voandzeia subterranea*) seed. *Res. J. Agric. Biol. Sci*., 3, 24-34.

Yigzaw Y., Gorton L., Solomon T. and Akalu, G (2004). Fermentation of seeds of teff (*Eragrostis teff*), grass pea (*Lathyrus sativas*), and their mixtures: aspects of nutrition and food safety. *Journal of Agriculture and Food Chemistry*, 52(5): 1163-1169.

Zhou, X., Song, Z., Yin, L., Zhao, Q., & Wu, Y. (2020). Effects of replacing fishmeal with Roselle seed meal on growth performance, digestibility, and serum biochemical parameters of Nile tilapia (*Oreochromis niloticus*). *Aquaculture* Reports, 17, 100351.

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