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Effect of Processing on Nutrient Composition and Utilization of Cassava Meal by Nile Tilapia: Review

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Abstract

This review is conducted with recent accessible articles to assess the role of different processing methods in improving the nutritional quality of cassava and growth response of Nile tilapia fed with processed cassava based diets. Different processing methods have an effect on the nutritional quality of cassava. Fermentation of cassava root after inoculating with yeast showed remarkable increase in protein content, lower ant nutritional factors and fiber content. Similarly, fermentation of cassava root with rumen filtrate and molasses showed better nutritional quality of cassava products. The rest types of processing, soaking, boiling, air drying and sun drying have positive role in reducing the level of toxic factors, but they do not increase the protein content of cassava meal. The inclusion of blanched cassava root and immersed cassava leafs in the diet of Nile tilapia demonstrates promising result on fish growth. The growth performance and feed intake of fish was improved when processed cassava based diet was supplied. After adequate processing of cassava products it is possible to prepare fish diet by mixing it with other feed stuffs. Further research on effects of processing methods on the nutrient content and utilization of cassava meal by Nile tilapia is highly recommended.

Keywords: Cassava; Nile Tilapia; Nutrient Content; Processing; Utilization

Introduction

In aquaculture, fish feed is a big issue because the price of feed is increasing from year to year. Particularly, fish feed made of fish meal and fish oil is very expensive and is unaffordable for farmers. Moreover, fish feed made of soybean, corn gluten is also expensive and also create computation with human consumption. Nutrition research that helps to reduce the cost of fish feeds without reducing their efficacy will be crucial to the successful development and commercialization of aquaculture in Africa using cheap and easily accessible feed feedstuff [1]. Different feed ingredients originated from animal and plant products can be used to prepare fish feed. According to Oloyede [2], cassava plant can be one of the ingredient to prepare fish feed with the inclusion of other feed sources like palm kernel cakes, soybean, maize and other supplements. Cassava crop is cheap and accessible in most parts of Ethiopia.

Cassava plant is a perennial that grow under the cultivation to a height of about 2.4m, the large palmate leaves ordinarily have five to seven lobes borne on a long slender petiole. They grow only toward the end of the branch [3]. Cassava is one of the most important food crops that constitute a considerable portion of the daily diet of the people and also serves as a major source of carbohydrate in Southern Ethiopia [4]. Although, cassava plant is recommended for fish feed, it is rapid perishable, has low protein content and contains high cyanide in all root tissues which is toxic to the consuming animal. Through simple processing techniques the protein content and perishability can be overcome. In addition, the processing tactic can detoxify toxic and ant nutritional compounds in the cassava product [5]. Therefore, the main objective of this seminar is to review different cassava processing methods and to understand the effect of different processing methods on the nutrient content and growth response of fish consumed it.

Effect of processing methods on nutrient composition and anti-nutritional factors of cassava meal

Different processing methods can affects the nutritional value of cassava roots through modification and losses in nutrients of high value [6]. In order to avoid and mitigate dietary cyanide exposure, the cyanogen, must be removed by processing before consumption. Efficient cassava processing methods break the root tissue entirely by releasing an endogenous enzyme, linamarase; this endogenous β-glucosidase enables the hydrolysis of Linamar in into glucose and ace-tone cyanohydrins [7]. Some of cassava processing methods are elaborated as follows.

Sun drying

Drying is the simplest method of processing. It reduces moisture, volume and cyanide content of tuber, thereby prolonging product shelf life. Drying has been widely accepted as an efficient processing method for cassava roots as it results in products that have longer shelf-life with relatively reduced cyanide content [8]. The rising of ash content of sundried, solid state fermented cassava products had been due to the reduction of moisture content of the cassava samples and an increased concentration of nitrogen free extracts within the samples [9]. The level of Linamarin in sun-dried cassava root parts showed an exponential reduction, corresponding with the moisture reduction, and stabilized when moisture levels reached about fifteen %. Linamar in degradation in thin root segments was significantly slower and less complete than in thick ones [10]. Linamar in reduction was greater when the interruption was earlier or longer and the dehydration rate influences Linamar in reduction negatively. Sun-drying is not very effective in linamarin

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removal, and speeding up the drying process. There is a potential for increasing the effectiveness of cyanogen removal by reducing the initial drying rate, followed by thorough final drying [10].

Sun-drying of whole cassava roots after milled or pounded into flour, reduces cyanide levels from 751 to 254 mg HCN/kg of dried roots. Direct sun-drying of cassava roots is an ineffective method for removal of cyanogens [11]. According to Ismaila et al. [9] the proximate composition of sun dried peeled cassava chips was 1.01% ash, 7.09% moisture, 4.2% fiber, 1.04% protein and 0.65% lipid. On the other hand Olugbenga and Oloruntola [12] indicated that the proximate composition of sun dried cassava peel was 5.48% CP, 10.5% fiber, 0.44% lipid, 5.27% ash, 70.48% NFE and 92.17% dry matter. Chhay et al. [13] also showed that Sun dried cassava root contains 2.95%CP and 84.9% dry matter.

Air drying

Total cyanide content of cassava chips could be decreased by only 10-30 percent through fast air drying [14]. Free hydrogen cyanide rapidly removed from the cassava chips through air drying processes, but only 8–12% of the total cyanide is present as free cyanide. The comparison of air-drying process at different temperatures indicated that 29% of the bound cyanide was removed by drying at 46.5°C; smaller losses were recorded at the higher temperatures [15].

Soaking

Soaking of cassava root normally preceded by cooking or fermentation; it provides a suitable larger medium for fermentation and allows for grater extraction of the soluble cyanide into the soaking water. The process removes about 20% of the cyanide in fresh root chips after 4 hours, although bound cyanide is only negligibly reduced [14]. The degree of soaking of cassava had an important effect on nutritional content in the processed samples, with the effect that the longer the extent of soaking the lesser the nutrient retention, especially the minerals [16].

According to Amsalu Nebiyu and Essubalew Getachew [17] soaking of cassava chips in water for about 24 h prior to sun drying reduced the HCN from 108.37 to 10.83 ppm (reduced by 90%) for NW-44/72 cassava variety. It was known that total hydrogen cyanide (HCN) content in cassava flour can be markedly destroyed (by more than 80%) by soaking of cassava chips in water. The study of Amsalu Nebiyu and Essubalew Getachew [17] was focused on the importance of soaking of cassava chips for at least 24 h prior to sun drying for a safe level of HCN in the flour. According to Aguihe *et al.*[18] the proximate composition of soaked and sun dried cassava peal was 5.75% CP, 14.83% fiber, 1.47% lipid, 5.68% ash, 70.1% NFE and 92.66% dry matter.

Boiling

Boiling is used in the processing of cassava roots in almost all countries where cassava is used as food. Boiling is not an efficient method for cyanide removal. The inefficiency of this processing method is due to the high temperature. At 100^{0}C linamarase, heat-labile, β-glycosides, is denatured and Linamar in cannot then be hydrolyzed into cyanohydrins [14]. Hence, moderate level of temperature is effective for cyanide removal and keeps its nutrients.

Boiled storage cassava roots have the best retention of nutrients compared with the other food products. Boiled cassava retained the highest amount of iron and zinc, also of total carotenoid of 73.5% [19].

As with soaking, the free cyanide of cassava chips is rapidly lost in boiling water, about 90% of free cyanide is removed within 15 minutes of boiling fresh cassava chips, compared to a 55% Reduction in bound cyanide after 25 minutes [20]. Cooking destroys the enzyme linamarase at about 72°C thus leaving a considerable portion of the glucoside intact.

According to Ismaila *et al.* [9] the proximate composition of boiled peeled cassava root was 0.75% ash, 60.05% moisture, 4.19% fiber, 0.94% protein and 0.15% lipid.

Fermentation

Cassava processing, especially fermentation primarily enhances nutritional properties through biosynthesis of vitamins, essential amino acids and proteins, by improving protein quality [21] and Fiber digestibility as well as the enhancement of micronutrient bioavailability and degradation of Anti- nutritional factors [21].

Yeast fermentation

Apart from the necessity of a sterile environment for the operation of submerged fermentation, enzymatic or acid treatment of carbohydrate is needed when yeasts are to be used as the microbial inoculums [22]. According to Sommai et al. [23] yeast fermented cassava peel can be nutritionally enhanced by yeast fermentation, thus is promising to be used as a protein source in ruminant feeding. Different forms of cassava root products such as chip can be successfully fermented with yeast (*S. cereviceae*) to obtain a final product with high crude protein and a relatively good profile of amino acids [24].

Although, cassava chip is considered as an energy source with low crude protein, it can increase crude protein content from 1-3% to 30.4% CP when fermented with yeast [25]. According to Polyorach et al.[24] the chemical composition of yeast fermented cassava chip are 90% Dry matter,97.2% Organic matter, 47.5% Crude protein, 7.9% Ether extract, 6.1% Neutral detergent fiber (NDF) and 4.3% Acid detergent fiber (ADF). On the other hand the finding of Sittisak *et al.* [26] showed that chemical composition of fermented cassava chips are 89.1% dry matter, 89.4% organic matter, 36.1% crude protein, 10.5% ash, 7.5% acid detergent fiber, 6.1% neutral detergent fiber and 3.3 metabolisable energy. On the other hand Sukruthai et al. [27] showed that the chemical composition of yeast fermented cassava pulp (YFCP) was 89.8% dry matter and 23.3% protein.

The finding of Krisada et al. [25] shows that the proximate composition of cassava root fermented by yeast was, increases in protein (by 13.5%) and fat contents (by 3%). Yeast (*S. cerevisiae)* fermented cassava products had very low hydrocyanic acid (HCN) contents (47.3 mg kg^{-1}). These levels were considered as safe for animal feeding and showed a remarkable increase in lysine content in the fermented cassava chip. The greatest acceptability, color, texture and aroma of enriched cassava chip were obtained after 10 days of bioprocessing. During yeast- cassava fermentation, carbohydrate content was reduced due to the possible transformation of some of the carbohydrate, which could be used as carbon sources for synthesis of protein or fat [28].

Molasses fermentation

According to Senthilkumar *et al.* [29] Molasses can be a source of quick energy and an excellent source of minerals for farm animals. Molasses contains calcium, sodium, potassium, magnesium and sulfur. Supplementing poor quality hay with molasses will increase feed intake and improve palatability. Molasses is important ingredient to reduce the dusty powdery nature of some finely ground cassava root. Molasses can be added to replace missing sugar and trace minerals and help with fermentation in cases of low quality forages especially with low sugar levels [29].

There was a slight decrease in crude protein, ether extract; NDF, ADF and ash with addition of molasses, while the dray matter and waste silage cassava (WSC) were significantly increase [30]. Silage pH was decreased when 2% of molasses was added to the feed [31]. The findings of Petterson [32] indicated that silage is considered to be of high quality when the pH is below 4.5. Lower pH of silage may come from higher lactic acid concentration in those silages. Lactic acid is the strongest acid in the silage, and its presence will decrease pH more efficiently than other volatile fatty acids [33].

Cassava pulp nutritive value could be enhanced by 4%Urea and 4% Molasses supplementation. But neutral detergent fiber (NDF) and acid detergent fiber (ADF) were decreased by the supplementation of molasses and molasses inclusion alone does not increase the protein content [34]. The concentrations of dry matter (from 26.9 to 29.53%) and crude protein (from 7.37 to 10.12%) were increased in silage treated with molasses. These were due to the high dry matter content of molasses used, and relatively higher CP content of molasses [35]. According to Ngo and Hans (2001), [30], the chemical composition of 6% molasses treated cassava silage was 324 DM, 18.8 CP, 10.4 either extract, 35.1 ADF, 49.9 NDF, 6 % ash and 4.3 Tannin. Similarly, the nutritive value of 2% molasses supplement cassava top silage was 18.9% dry matter, 93.1% organic matter, 39.7% NDF, 27.1 ADF and 28.2% crude protein [31].

Rumen fermentation

The study of Adeyemi *et al.* [36] indicated an improvement in the Crude Protein value of cassava root meal when enriched with common farm animal wastes and fermented with bovine rumen filtrate. Dairo *et al.* [37] reported that there was a decline in Crude fiber content after fermentation of cassava root meal. On the contrary, the finding of Francisco and Mathews [38] indicates that there is an increase in crude fiber (from 1.6 to 8.5) with the fermentation of cassava root with rumen filtrate. Crude protein level also increased (from 1.7% to 7.6%) after fermentation.

Adeyemi *et al.* [36] also stated that, fermentation with rumen filtrate significantly increased the ether extract, protein and moisture content of cassava root meal. But, there were a decline in dry matter content which was associated with increased moisture content with advanced fermentation duration. The proximate nutrient composition of fermented cassava meal- layers manure mixture was 87.3% dry matter, 7.6% crude protein, 8.5% crude fiber, 5.4% ether extract, 3.6% ash and 3220 ME /k cal/kg [40].

Growth response of fish in different processed cassava based diets

Different research findings have showed that the inclusion of processed cassava leaf demonstrates promising result on fish growth. Ng and Wee [39]suggested that cassava leaf meal can be potentially used in the diet of Nile tilapia without compromising the growth and survival of the fish. Hassan et al. [40]reported that cassava leaf meal can be used up to 20% replacement in the diets for African catfish without negatively impacting the growth and nutrient utilization. The mean weight of catfish fed diet 100% cassava leaf was very low compared to those fed other diets. But, fish that fed a diet 25% cassava had the highest mean weight among the varied levels of substitution of cassava leaf meal. Also, the inclusion of 25% of processed cassava leaf meal showed a good growth of catfish with 1.48%, 0.12 and 1.1, SGR, FCR and FCF respectively [41].

According to Udo and John [42] the growth rate of catfish fed diets containing cassava leaves was improved when the leaves were subjected to double immersion in water prior to feeding. The feed utilization of catfish was also improved by using this processing method (double immersion of cassava leaves in water prior to feeding). There were no negative effects on fish survival by inclusion of cassava leaves in the diet. Fish health was not negatively affected by cassava leaf inclusion and showed best growth parameters, 4.24% specific growth rate (SGR), 1.97 feed conversion ratio (FCR), 2.73 protein efficiency ratio (PER) and 91.9% survival rate. The substitution of Noug seed cake with cassava leaf meal has resulted in improvement of final body weight gain, total body weight gain and daily body weight gain among the broilers fed with the 4% substitution levels [43].

According to Maima *et al.* [44] the diets containing a mixture of 75% broiler concentrate and 20% cassava (high energy) meal were found to support a higher growth of GIFT tilapia than fish fed the fish standard diet from (control) diet. The better values for feed intake, body weight and FCR (2.97) of juvenile GIFT tilapia fed HEC (high energy cassava) diet may have been due to the processing of the cassava prior to pelleting, which reduced the anti-nutrients in cassava making them more palatable. According to Arthur *et al.* [45] the juvenile tilapia fed high-energy universal concentrate blended with 31% cassava meal shows good growth performance of 2.68% SGR, 2.8 FCR and 1.85 PER. The study founded by Oloyede [2] indicated that *O.niloticus* that fed the mixture of 60% Palm kernel cake (PKC) and 40% cassava flour meal (CFM) inclusion was grew 1.32 SGR, 2.96 FCR and 0.97 PER.

Cassava leaf protein concentrate (CLPC) has similar nutritional value with solvent-extracted soybean meal and it supported good growth and diet utilization in *O. niloticus* and *T. zillii* without histological disorders in their livers, up to 60% and 80% substitution of SBM, respectively. When the CLPC was substituted at 80% of SBM in *O. niloticus* diet, growth response and diet utilization were compromised, which was caused by reduced feed intake, protein and energy digestibility. It also elicited alterations in the liver histology. Residual anti-nutrients were mainly responsible for these effects. The suitability of CLPC as dietary protein for tilapias will depend on further reduction/removal of inherent anti-nutrients as well as improving digestibility [46].

Conclusion and recommendations

Due to the high cost of conventional feeds searching of cheap and easily accessible feed stuff is crucial to the successful development and commercialization of aquaculture. Although, cassava is cheap and easily accessible, it contains low protein and toxic factor Linamar in which results cyanide poisoning. Hence, cassava should subject to different processing methods to improve its nutritional value and to reduce its toxic factor. Different processing methods such as peeling, soaking, drying, boiling, ensiling and fermentation have positive role in the nutritional quality of cassava. Fermentation of cassava with the inclusion of different nutrients such as yeast, molasses and rumen can increase the nutritional value and detoxify its anti-nutritional factors. After adequate processing it is possible to prepare fish diet by mixing cassava with other feed stuffs. The growth performance and feed intake of fish was improved when processed cassava was included in the diet of Nile tilapia. Further research on effects of processing methods on the nutrient content and utilization of cassava meal by Nile tilapia is highly recommended.

References

1. Asaminew K (2012) Utilization of locally available feedstuffs for small-scale aquaculture production in Ethiopia. (Doctoral dissertation, University of Natural Resources and Life Sciences Vienna).

2. Oloyede Oluponmile Oyeb, Tech Futm (2018) Performance of Oreochromis niloticus (LINNAEUS, 1798) reared in cages feed composite palm kernel cake and cassava flour.

3. Grace MR (1977) Cassava processing (No. 3) Rome: Food and Agriculture Organization of the United Nations.

4. Tadesse T, Degu G, Shonga E, Mekonen S, Addis T, et al. (2013) Current status, Potentials and challenges of Cassava production, processing, marketing and utilization: Evidence from Southern Ethiopia. Greener J Agric Sci 3(4): 262-270.

5. Ospina B, Wheatley C (1992) Processing of cassava tuber meals and chips. Roots, tubers, plantains and bananas in animal feeding 95: 57-85.

6. Onyenwoke CA, Simonyan KJ (2014) Cassava post-harvest processing and storage in Nigeria: A review. Afr J Agric Res 9: 3853-3863.

7. Conn EE (1969) Cyanogenic glucosides. J Agric Food Chem 17: 519-526.

8. Habib A (2017) Determination of cyanogenic glycosides in roots of cassava plant and some cassava products.

9. Ismaila AR, Alakali JS, Atume TG (2018) Effect of Local Processing Techniques on the Nutrients and Anti-Nutrients Content of Bitter Cassava (Manihot Esculenta Crantz). Am J Food Technol 6: 92-97.

10. Essers AA, Van der Grift RM, Voragen AJ (1996) Cyanogen removal from cassava roots during sun-drying. Food Chem 55: 319-325.

11. Mlingi NV, Bainbridge Z (1994) Reduction of cyanogen levels during sun-drying of cassava in Tanzania. Acta Hortic 375: 233-240.

12. Oloruntola OD (2020) Effect of dietary cassava peel meal supplemented with methionine and multienzyme on hemo-biochemical indices, digestibility, and antioxidants in rabbits. J Basic Appl Zool 81(1): 1-11.

13. Chhay TY, Khieu B, Noy S, Preston TR, Tin Maung A (2015) Effect of sun-dried and fresh cassava leaves on growth of Tilapia (Oreochromis niloticus) fish fed basal diets of rice bran or rice bran mixed with cassava root meal. Livest Res Rural Dev 6:1-12.

14. Wassie AS (2020) Cassava Production and Field Management in Ethiopia. J Agric Hortic 2: 1-10.

15. Pierre MA, Eliane HG, Geraldine MT, Georges NA (2020) Varietal influence of cassava on chemical composition and consumer acceptability of Gari. Int J Food Sci Technol 56: 1239-1246.

16. Adepoju OT, Adekola YG, Mustapha SO, Ogunola SI (2010) Effect of processing methods on nutrient retention and contribution of cassava (Manihot spp) to nutrient intake of Nigerian consumers. African J Food Agric Nutr Dev 10: (2).

17. Amsalu Nebiyu and Essubalew Getachew (2011) Soaking and drying of cassava roots reduced cyanogenic potential of three cassava varieties at Jimma, Southwest Ethiopia. African Journal of Biotechnol 10: 13465-13469.

18. Aguihe PC, Kehinde AS, Ilaboya II, Ogialekhe P (2016) Effect of Dietary Enzyme (Maxigrain®) Supplementation on Carcass and Organ Characteristics of Broiler Finisher Chickens Fed Cassava Peel Meal Based Diet. Int J Res Agric Forestry 3: 1-6.

19. Maziya-Dixon B, Awoyale W, Dixon A (2015) Effect of processing on the retention of total carotenoid, iron and zinc contents of yellow fleshed cassava roots. J Food Nutr Res 3: 483-488.

20. Cooke RD, Maduagwu EN (1985) The effect of simple processing on the cyanide content of cassava chips. J Food Technol 13: 299-306.

21. Motarjemi Y (2002) Impact of small scale fermentation technology on food safety in developing countries. Int J Food Microbiol 75: 213-229.

22. Balagopalan C, Padmaja G, George M (2012) Improving the nutritional value of cassava products using microbial techniques. Roots, tubers, plantains and bananas in animal feeding. FAO Animal Production and Health paper 95.

23. Sommai S, Ampapon T, Mapato C (2020) Replacing soybean meal with yeast-fermented cassava pulp (YFCP) on feed intake, nutrient digestibilities, rumen microorganism, fermentation, and N-balance in Thai native beef cattle. Trop Anim Health 52: 2035-2041.

24. Polyorach P, Wanapat, M, Wanapat S (2012) Increasing protein content of cassava (Manihot esculenta, Crantz) using yeast in fermentation. Khon Kaen Agr J 40:178-182.

25. Boonnop K, Wanapat M, Nontaso N, Wanapat S (2009) Enriching nutritive value of cassava root by yeast fermentation. Sci Agric 66:616–620.

26. Khampa S, Chuelong S, Kosonkittiumporn S, Khejornsart P (2010) Manipulation of yeast fermented cassava chip supplementation in dairy heifer raised under tropical condition. Pak J Nutr 9: 950-954.

27. Sommai S, Ampapon T, Mapato C, Totakul P, Viennasay B, et al. (2020) Replacing soybean meal with yeast-fermented cassava pulp (YFCP) on feed intake, nutrient digestibilities, rumen microorganism, fermentation, and N-balance in Thai native beef cattle. Trop Anim Health Prod 52(4): 2035-2041.

28. Lehninger AL, Nelson DL, Cox M (1987) Bioenergetics and metabolism, principle of biochemistry. 2nd Preprint, CBS Publisher and Distribution, Newdelhi: 313-356.

29. Senthilkumar S, Suganya T, Deepa K, Muralidharan J, Sasikala K (2016) Supplementation of molasses in livestock feed. Int J Sci Environ Technol 5: 1243-1250.

30. Van MN, Wiktorsson H (2001) Cassava top ensiled with or without molasses as additive effects on quality, feed intake and digestibility by Heifers. Asian-Aust. J Anim Sci 14: 624-630.

31. Kang S, Wanapat M, Nunoi A (2018) Effect of urea and molasses supplementation on quality of cassava top silage. J Anim Feed Sci 27: 74-80.

32. Petterson K (1988) Ensiling of forages: Factors affecting silage fermentation and quality.

33. Cao Y, Takahashi T, Horiguchi K (2009) Effects of addition of food by-products on the fermentation quality of a total mixed ration with whole crop rice and its digestibility, preference, and rumen fermentation in sheep. Anim Feed Sci Technol 151: 1-11.

34. Thitima N, Metha W, Anusorn C, Sungchhang K, Kampanat P, et al. (2018) Improvement of nutritive value of cassava pulp and in vitro fermentation and microbial population by urea and molasses supplementation. J Appl Anim Res 46: 242-247.

35. Erol BA, Akif M, HabiMU (2005) The Effects of Formic Acid, Molasses and Inoculant as Silage Additives on Corn Silage Composition and Ruminal Fermentation Characteristics in Sheep. Turk J Vet Anim Sci 29: 469-474.

36. Adeyemi OA, Eruvbetine D, Oguntona T, Dipeolu MA, Agunbiade JA (2007) Enhancing the nutritional value of whole cassava root meal by rumen filtrate fermentation. Arch Zootec 56: 261-264.

37. Dairo FA, Aina A, Omoyeni L, Adegun MK (2011) Ensiled Cassava Peel and Caged Layers' Manure Mixture as Energy Source in Broiler Starter diet. J Agric Sci Technol 1: 519-524.

38. Francisco KA, Mathews MO (2014) Effects of replacing maize meal with rumen filtrate-fermented cassava meal on growth and egg production performance in Japanese quails (Cortunix japonica). J Adv Vet Anim Res 1(3): 100-106.

39. Ng WK, Wee KL (1989) The nutritive value of cassava leaf meal in pelleted feed for Nile tilapia. Aquac 83: 45-58.

40. Hassan M, Wakil UB, Gamawa AI (2017) Effects of Cassava Leaf Meal on Growth Performance and Nutrient Utilization of African Catfish in the Semi-Arid Zone of Nigeria. Int J Sci Technol 6: 689-693.

41. Odo GE, Agwu JE, Nweze NO, Clement S, Alfreda NO, et al. (2016) Growth performance and nutrient utilization of Clarias gariepinus fed with different dietary levels of processed cassava leaves. Afr J Biotechnol 15(24):1184-1192.

42. IU Udo and J F John (2015) Effect of processing methods on the utilization of cassava (Manihot esculenta Crantz) leaf meal (CLM) by African catfish (Clarias gariepinus). Livest Res Rural Dev 27(8): 1-8.

43. Melesse A, Masebo M, Abebe A (2018) The Substitution Effect of Noug Seed (Guizotia Abyssinica) Cake with Cassava Leaf (Manihot Escutulata C.) Meal on Feed Intake, Growth Performance, and Carcass Traits in Broiler Chickens. J Anim Husb Dairy Sci 2:1-9.

44. Maima S, Workneh A, Densley T, Mark B, Suzi G (2017) Growth performance of juvenile genetically improved farmed tilapia (GIFT) fed on broiler concentrate mixed with sweet potato or cassava meal. Aust Center Int Agri Res: 244-251.

45. Arthur R, Martin L, Maima S, Workneh Ayalew (2017) Growth performance of juvenile genetically improved farmed tilapia (GIFT) fed diets with two levels of rice bran or a high-energy broiler concentrate mixed with cassava meal. Aust Center Int Agri Res: 244-251.

46. Fagbenro O, Oresegun A, Nwanna L, Ilona P, Olurotimi O et al. (2017) Performance of Diets for Oreochromis niloticus and Tilapia zillii by Inclusion of Cassava Leaf Protein Concentrate as Partial Replacement for Solvent-Extracted Soybean Meal. Applied Trop Agric 22: 16-23.