REPLACEMENT OF SOYBEAN WITH RAW AND PROCESSED DUCKWEED AFFECT THE PERFORMANCE AND HAEMATOLOGICAL INDICES OF NILE TILAPIA

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ABSTRACT

This research investigated the effects of treated duckweed meal (DWM) supplemented diets on growth, nutrients utilization and haematology of Oreochromis niloticus as soybean substitute. Nile tilapia were fed isonitrogenous diets (37% crude protein) formulated on protein for protein basis and prepared from differently treated DWM of raw (Ra), cooked (Co) and soaked in potash (So) by gradual replacement of soybean meal at Control 0; Ra5, Ra10, Ra15%; Co5, Co10, Co15% and So5, So10, So15% respectively. Juvenile O. niloticus (n=300; 12.0±0.10g; 10fish tank^{-1}) were randomly allocated to triplicate treatments in 3×4×3 factorial experiment. The fish were fed to satiation twice daily for 84 days. Growth, nutrient utilization and haematological indices were studied. There were no significant ($p>0.05$) differences in performance and nutrients utilization indices of MWG, SGR and FCR amongst the treatments, except NPU (%) and survival (%) which were significantly ($p<0.05$) highest (85.69±1.38) in Ra10 and 95.00±3.91 in Control (0%) but lowest (75.75±1.38) in Co10 and 70.00±3.91 in Co10, respectively. PCV and haemoglobin ranged from 18.00±1.57 (Ra15) to 26.00±1.57 (Co15) and 5.95±0.50 (So10) to 7.95±0.50 (Co15), respectively, were not significantly ($p>0.05$) different from the control (0%). This Processing method did not improve the performance of O. niloticus fed duckweed feed efficiently above soybean, which may be due to other factors in the dietary treatments.

Keywords: Aquatic weed, blood indices, nutrient utilization.

INTRODUCTION

Aquaculture has been adjudged the fastest growing food-producing sector of agricultural industry around the world (Ogunji and Wuertz, 2023). Production from aquaculture is increasing globally (Mmanda *et al.,* 2020) due to new technological advances and increased demands for fish as a source of animal protein (Assefa and Abunna, 2018). Expansion of the industry has resulted into more sophisticated intensive culture methods producing higher yields and requiring high nutritional input to meet its growing trend (Rico *et al.,* 2012). The success of commercial aquaculture operations depends largely on the availability of suitable and quality diets, which provide required nutrients for optimum growth of fish at minimal cost (Mohapatra and Patra, 2013).

Soybean meal is the most nutritive plant feed stuff used in livestock feeds production with high competition for utilization by man (Orire and Ozoadibe, 2015). The high cost of soybean in local and international market implies the need to find alternative to its use that will not compete with human needs and which will inevitably increase the protein production from livestock.

Efforts have been geared towards the utilization of plant materials especially aquatic weeds as possible feed ingredients in aquaculture feed (Nwanna and Falaye, 1997; Nwanna *et al.,* 2008; Solomon and Okomoda 2012; Sotolu and Sule, 2011). Duckweed has been identified as a potential plant with great nutritional values, comparable to soybean meal that is capable of substituting it in practical and commercial diets for some economic aquaculture fish (Aghoghovwia *et al.,* 2018). However, despite the availability and nutritional values of plant origin feed stuffs, their use has limitations (Agbo *et al.,* 2011; Phengnuam and Suntornsuk, 2013); due to the presence of anti-nutrients factor in them (Liener, 2003). Processed DWM have been used in fish feed and as soybean replacement on weight for weight basis at various inclusion levels (Flores-Miranda *et al.,* 2014; Pinandoyo *et al.,* 2015; Sogbesan *et al.,* 2015; Ibrahim *et al.,* 2017; Aghoghovwia *et al.,* 2018).

The effects of this aquatic feedstuff are less studied on the species been cultured; hence this research investigated the effect of feeding processed duckweed meal on performance and physiological indices of *O. niloticus* juveniles (Falaye *et al.*, 2022). Haematological parameters investigations have been used to determine the physiological state of animals (Afia and Offor, 2016). The nutritional status of fish is also one of the most important factors influencing the blood values (Congleton and Wagner, 2006). Haematological indices have been known to be important tools for determining the health status of fish in response to the dietary manipulations (Klinger *et al.*, 1996; Mohammed and Sambo, 2007). This study investigated factor effects of processed DWM of graded levels of raw, cooked and soaked duckweed meals supplemented diets as soybean replacement on the growth performance, nutrients utilization and physiological response of *Oreochromis niloticus* juveniles which is yet to be documented.

MATERIALS AND METHODS

The fresh duckweed collected was divided into three (3) processing groups for preparation. Raw Duckweed: 37.5 kilogram of the fresh duckweed was air-dried under shade; Cooked Duckweed: 37.5 kilogram was boiled at 100^0C for 5 minutes (Sogbesan *et al.*, 2015) and Potash Treated Duckweed: 37.5 kilogram was soaked in potash (Maize cob ash) solution at 5 grams per litre for 24 hours (Vadivel and Pugalenthi, 2008), treated samples were drained and air-dried under shade. The duckweed samples were milled into powder using home milling/grinding machine and packed in air tight polythene bag in preparation for feed production.

Ingredients in Table 1 were combined with raw and processed DWM for the experimental diets' formulation and preparation. Some of the ingredients were milled for particle size reduction to powder and sieved with 1.0mm sieve mesh to obtain fine particle before inclusion in feed preparation for easy uptake and digestion by the experimental fish. Analysis of raw and processed duckweed samples, other variable ingredients and experimental feeds was according to the methods of AOAC (2005).

Table 1 Gross composition of experimental Diets (DW g/100g)

Ingredients	Control	Ra5	Ra10	Ra15	Co5	Co10	Co15	So5	So10	So15
DWM	0.00	4.41	8.82	13.23	3.40	6.80	10.20	3.92	7.84	11.76
SBM	50.00	47.50	45.00	42.50	47.50	45.00	42.50	47.50	45.00	42.50
Fishmeal	22.59	22.59	22.59	22.59	22.59	22.59	22.59	22.59	22.59	22.59
Maize	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63
Methionine	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Lysine	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Vitamin C	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
DCP	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Salt	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
*Premix	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Palm oil	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Starch	6.68	4.77	2.86	0.95	5.78	4.88	3.98	5.26	3.84	2.42
TOTAL	100	100	100	100	100	100	100	100	100	100
Crude protein	36.97	36.59	36.88	36.98	36.76	36.55	37.00	36.48	36.95	36.47
Moisture content	8.94	9.02	9.06	8.21	8.92	8.58	8.88	8.64	9.02	9.06
Ash	5.68	6.40	7.14	7.87	6.15	6.58	7.30	6.91	6.75	7.55
Fat	4.64	4.25	4.28	4.37	4.18	4.21	4.32	4.22	4.32	4.14
Fibre	3.87	3.69	4.13	4.23	3.90	4.03	4.14	3.84	4.09	4.22

* 100 g contains: vitamin A-960,000IU; vitamin D3-160,000IU; vitamin E-0.89g; vitamin K-0.16g; vitamin B1-80mg; vitamin B2-0.32g; vitamin B6-0.12g; vitamin B12-0.8mg; pantothenic acid-0.89; niacin-1.6g; folic acid-80mg; biotin-4mg; choline chloride-40g

DWM = Duckweed meal; SBM = Soybean meal; DCP = Dicalcium phosphate; C=Control 0%; Ra5=Raw Duckweed 5% DWM; Ra10=Raw Duckweed 10% DWM; Ra15=Raw Duckweed 15% DWM; Co5=Cooked Duckweed 5% DWM; Co10=Cooked Duckweed 10% DWM; Co15=Cooked Duckweed 15% DWM; So5=Soaked in Potash 5% DWM; So10=Soaked in Potash 10% DWM; So15=Soaked in Potash 15% DWM.

Experimental Design and Set up

The study was a completely randomized 3×4×3 factorial experimental design. Thirty (30) transparent rectangular plastic bowls of 30 litres capacity arranged in randomized position were used for the experiment, and filled with 25 litres clean water. Each bowl was stocked with ten (10) experimental fish (*O. niloticus*) juveniles' average weight 12.0±0.10g. Tilapia (*O. niloticus*) harvested from the College Fish Farm was conditioned for two

(2) weeks for stability. 300 juveniles were selected, weighed and distributed into the thirty (30) bowls used for the experiment and acclimatised for a period of twenty (21) days. During acclimatization, they were fed with commercial floating feed and monitored daily for mortality. The fish lost to mortalities during acclimatization were replaced and bulk weighed again at the commencement of the experiment to establish their initial weight before feeding trial. The fish were fed to satiation with the experimental diets twice daily at 8:00am and 6:00pm. 30g each of the experimental feeds were weighed out for each bowl. The leftover feeds were weighed weekly during sampling and subtracted from the initial quantity to obtain the total feed consumed by the experimental fish during previous week(s). Sampling of the experimental fish was carried out weekly. The fish were bulk weighed on an electronic sensitive weighing balance (Model HZT-A3000).

Growth and nutrients indices

Growth indices such as weight gained (WG), specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER), etc., using the weekly weight and quantity of feed were determined.

Weight Gain (WG): WG = Final fish body weight – Initial fish body weight

Percentage Weight Gain: $\left(\% \text{ WG} = \frac{(\text{Final Weight} - \text{Initial Weight}) \text{ X } 100}{\text{Initial Weight}}\right)$.

Specific Growth Rate: $\left(\text{SGR} = \frac{(\text{Log Final Weight} - \text{Log Initial Weight}) \text{ x } 100}{\text{Time}}\right)$.

Feed Conversion Ratio: $\left(\text{FCR} = \frac{\text{Feed Consumed (g)}}{\text{Weight Gain (g)}}\right)$

Feed Efficiency Ratio: $\left(\text{FER} = \frac{(\text{Final weight} - \text{Initial weight}) \text{ x } 100}{\text{Feed intake (g)}}\right)$

Protein Efficiency Ratio: $\left(\text{PER} = \frac{\text{Mean weight gain (g)}}{\text{Mean protein intake (mg)}}\right)$

Net Protein Utilisation: $\left(\text{NPU} = \frac{100 \text{ x Carcass protein gain}}{\text{Protein fed}}\right)$

Collection and Analysis of Blood Samples

Randomly selected fish (n=20) from two replicate in each of the treatments were sampled for blood at the end of the experiment, using 2ml hypodermal syringe and needle through caudal spinal cord puncture for haematological analysis. About 2ml of blood samples were collected into a sterile heparinized (anti-coagulant agent) EDTA bottles. The samples were analysed at the Clinical Pathology Laboratory of the Department of Veterinary Sciences, University of Ibadan for packed cell volume (PCV), heamoglobin (Hb), red blood cells (RBC), white blood cells (WBC) and lymphocytes (L) according to Joshi *et al.*, (2002), while MCV, MCHC and MCH were calculated.

Mean corpuscular volume: MCV $(\mu^3) = \frac{\text{PCV x } 10}{\text{Er}}$

Mean corpuscular haemoglobin concentration: MCHC $(\%) = \frac{\text{Hb x } 100}{\text{PCV}}$

Mean corpuscular haemoglobin: MCH $(\text{pg}) = \frac{\text{Hb x } 10^2}{\text{Er}}$

Statistical Analysis

Two-ways analysis of variance (ANOVA) was used for data obtained from this experiment. Test for significance at P<0.05 was by Duncan's multiple range test using IBM SPSS version 21.

RESULTS

Proximate composition of test ingredients and major feedstuffs

The results of the proximate analysis of the test ingredients (raw and processed duckweed meal) are presented in Table 2 alongside the percentage crude protein of the major ingredients.

Table 2 Proximate composition of raw and treated duckweed meal and major feed stuffs (g/100g dry matter)

Parameters (%)	Samples					
	Ra	Co	So	Fishmeal	SBM	Maize
Dry Matter	92.02	92.40	91.95	92.83	89.00	90.23
Moisture content	7.98	7.60	8.05	7.17	11.00	9.77
Crude Protein	22.70	29.45	25.50	68.62	39.95	8.05
Ash	19.80	17.50	17.00	11.67	5.67	1.08
Ether Extract	3.30	3.20	3.50	6.97	3.50	4.50
Crude Fibre	7.70	8.30	8.10	0.89	6.50	1.79
NFE	38.52	33.95	37.85	4.68	33.38	84.81

NFE = Nitrogen Free Extract, SBM = Soybean meal, Ra = Raw DWM, Co = Cooked DWM, So = Soaked in potash DWM

Effect of processing methods and inclusion levels of raw and treated duckweed meals on growth response and nutrients utilisation of *O. niloticus* juveniles.

The effects of processing methods and inclusion levels of raw and treated duckweed meals on growth response of *O. niloticus* juveniles are found on Table 3. The results showed significant differences in the MIW of the experimental fish in some treatment, but without differences amongst some. However, despite the differences in the MIW of the experimental fish, there were no significant differences in the MFW, MWG, %MWG and SGR, amongst the treatments and control experiment. The MWG and SGR was highest in Control diet followed by Ra10 and Ra15. Dietary MWG was highest in Ra treatment over Co and So treatment. The protein intake was highest in Co treatment over Control; Ra and So treatments. The percentage survival was higher in the Control than Co10, but not different from other treatments significantly. The results showed no significant ($p>0.05$) differences in values of FCR, FER, PI, PER and PPV across the treatments and Control experiment, though these indices varied across the treatments. There were significant differences in NM among the treatments. The value of NM in the Control was highest in Control than the treatments, while NPU was highest in Ra treatment respectively.

Table 3 Growth performance and nutrients utilisation of *O. niloticus* juveniles in response to the effects of processing methods and inclusion levels of raw and treated duckweed meals

Indices	Control	Ra5	Ra10	Ra15	Co5	Co10	Co15	So5	So10	So15	SEM ±
MIW(g)	12.00^{b}	11.90^{c}	12.10^{a}	12.00^{b}	11.90^{c}	12.10^{a}	12.00^{b}	11.90^{c}	12.10^{a}	12.00^{b}	0.03
MFW (g)	20.66	19.99	20.52	20.11	19.69	19.64	18.90	19.30	19.86	18.98	1.36
MWG (g)	8.66	8.09	8.42	8.11	7.79	7.54	6.90	7.40	7.76	6.98	1.37
% MWG	72.17	67.96	69.59	67.61	65.48	62.29	57.46	62.16	64.16	58.15	11.42
SGR (g/day)	0.96	0.92	0.94	0.92	0.87	0.86	0.81	0.86	0.88	0.81	0.12
% Survival	95.00^{a}	85.00^{ab}	90.00^{ab}	90.00^{ab}	75.00^{ab}	70.00^{b}	75.00^{ab}	80.00^{ab}	80.00^{ab}	80.00^{ab}	3.91
FCR	2.18	2.11	2.10	2.14	2.69	2.26	2.57	2.36	2.23	2.56	0.40
FER	0.52	0.48	0.50	0.48	0.40	0.45	0.39	0.44	0.46	0.41	0.08
PI (g/100g diet/fish)	716.75	748.26	730.40	714.74	788.71	740.66	799.13	737.64	753.42	722.33	31.16
PER	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
PPV	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.00
NM	530.06^{a}	501.86^{ab}	514.17^{ab}	500.67^{ab}	448.68^{d}	495.58^{bc}	481.13^{bcd}	466.36^{cd}	504.36^{ab}	491.7^{bc}	6.32
NPU (%)	81.32^{ab}	83.09^{ab}	85.69^{a}	81.90^{ab}	75.75^{b}	76.56^{b}	76.22^{b}	76.76^{b}	81.98^{ab}	80.20^{ab}	1.38

Means ±SE *with different superscripts within the same rows are significantly different ($p<0.05$)*. PI=Protein Intake, PER=Protein Efficiency Ratio, PPV=Protein Productivity Value, NM=Nitrogen Metabolism, NPU=Net Protein Utilization, FCR= Feed Conversion Ratio, FER= Feed Efficiency Ratio. C=Control 0%; Ra5=Raw Duckweed 5% DWM; Ra10=Raw Duckweed 10% DWM; Ra15=Raw Duckweed 15% DWM; Co5=Cooked Duckweed 5% DWM; Co10=Cooked Duckweed 10% DWM; Co15=Cooked Duckweed 15% DWM; So5=Soaked in Potash 5% DWM; So10=Soaked in Potash 10% DWM; So15=Soaked in Potash 15% DWM.

Effects of raw and treated duckweed meals on haematological parameters of *O. niloticus* juveniles.

The results of processing effects on haematological parameters for graded levels of raw and treated duckweed meals diets fed *O. niloticus* juveniles are shown on Table 4. From the results, it was observed that Co as a treatment method significantly ($p<0.05$) increased the PCV and RBC of the experimental fish, which was not significantly different ($p>0.05$) from So. The values for MCH were higher in So than Ra and Co treatments which were not significantly different from each other. Other parameters such as Hb, Platelets and MCHC were not significantly in the processing methods and Ra treatment. The values of Lym and Eo were significantly higher in Co than Ra and So treatments, which were not different from each other significantly. The values of Basophils (Ba) were not different amongst the treatment methods.

Table 4 Haematological and differential white blood cell count responses of *O. niloticus* juveniles in response to the effects of processing methods and inclusion levels of raw and processed duckweed meals

Indices	Control	Ra5	Ra10	Ra15	Co5	Co10	Co15	So5	So10	So15	SEM ±
PCV (%)	21.00	20.00	19.50	18.00	22.50	20.50	26.00	21.00	19.50	19.50	1.57
Hb (g/100ml)	6.53	6.70	6.20	5.60	7.15	6.35	7.95	6.80	5.95	6.20	0.50
RBC ($\times10^6$ µl)	1.39^{b}	1.36^{b}	1.60^{b}	1.30^{b}	1.31^{b}	1.47^{b}	2.45^{a}	1.33^{b}	1.15^{b}	1.32^{b}	0.15
WBC ($\times10^3$ µl)	13.15^{ab}	15.23^{a}	13.68^{ab}	13.38^{ab}	13.75^{ab}	11.83^{b}	13.10^{ab}	12.50^{ab}	12.18^{ab}	12.83^{ab}	0.58
Plat ($\times10^4$/ml)	14.33^{ab}	11.00^{ab}	10.60^{b}	12.70^{ab}	12.55^{ab}	11.25^{ab}	14.85^{a}	12.90^{ab}	12.15^{ab}	12.65^{ab}	0.82
MCV (fl)	152.65	139.50	121.60	147.08	108.46	140.40	172.08	147.33	170.21	157.84	15.40
MCH (pg/cell)	47.35^{abc}	43.41^{bc}	38.56^{cd}	48.92^{ab}	33.25^{d}	43.43^{bc}	54.67^{a}	46.84^{abc}	51.93^{ab}	51.10^{ab}	2.15
MCHC (g/dl)	3.11^{ab}	3.12^{ab}	3.17^{ab}	3.33^{a}	3.06^{b}	3.10^{b}	3.18^{ab}	3.18^{ab}	3.05^{b}	3.24^{ab}	0.06
Lym (%)	51.33^{b}	48.00^{ab}	49.00^{ab}	42.50^{c}	48.50^{ab}	51.50^{b}	61.00^{a}	48.00^{ab}	45.00^{ab}	45.50^{ab}	1.61
He (%)	40.67^{b}	45.00^{ab}	45.00^{ab}	50.00^{a}	44.50^{ab}	40.50^{b}	31.00^{c}	44.50^{ab}	49.50^{a}	47.50^{ab}	1.84
Mo (%)	3.00^{abc}	3.50^{abc}	3.00^{abc}	4.50^{a}	2.00^{c}	3.50^{abc}	2.50^{bc}	4.00^{ab}	3.50^{abc}	2.50^{bc}	0.40
Eo (%)	4.67^{ab}	3.50^{ab}	2.50^{ab}	2.50^{ab}	5.00^{a}	4.00^{ab}	5.50^{a}	3.50^{ab}	1.50^{b}	4.00^{ab}	0.68
Ba (%)	0.33	0.00	0.50	0.50	0.00	0.50	0.00	0.00	0.50	0.50	0.25

Means ±SE *with different superscripts within the same rows are significantly different ($p<0.05$)*, C=Control 0%; Ra5=Raw Duckweed 5% DWM; Ra10=Raw Duckweed 10% DWM; Ra15=Raw Duckweed 15% DWM; Co5=Cooked Duckweed 5% DWM; Co10=Cooked Duckweed 10% DWM; Co15=Cooked Duckweed 15% DWM; So5=Soaked in Potash 5% DWM; So10=Soaked in Potash 10% DWM; So15=Soaked in Potash 15% DWM.

DISCUSSION

Growth performance of Nile tilapia (*O. niloticus*) juveniles fed raw and treated duckweed (*L. minor*) meals-based diets

Increasing fish yield in aquaculture can only be achieved by using locally available feed resources, which are cheap and also meet the nutritional requirements for optimal fish growth. Duckweed have been adjudged to meet the nutrient requirement for herbivores fish (Andriani *et al.,* 2019) and its passage through the gastrointestinal tract enhanced fish growth leading to improved fish performance (Fiordelmondo *et al.,* 2022). Weight gain and SGR are useful measurement of feed productivity (Falaye *et al.*, 2016). The results of the effects of treatment methods showed that the experimental fish (*O. niloticus)* in this study utilized protein in the experimental diets for growth. This was observed from the increase MWG (g/fish) of the dietary fed fish progressively. However, inclusion of the differently processed DWM performed below expectation in the study when compared to the control diet. This was contrary to the findings of Fiordelmondo *et al.,* (2022) who reported improved performance for Rainbow trout fed DWM diet.

The SGR results were observed to be lower than 1.31 and 1.41 reported in the works of Solomon and Okomoda (2012) when *O. niloticus* fingerlings was fed with raw duckweed meals at 5% and 10% inclusion levels, but comparable to those fed at 15%, 20% and 25% inclusion levels in this study. However, the present results were found to be higher than when *Clarias gariepinus* juveniles were fed 50% supplemental soybeans replacement levels of raw, sundried, blanched and soaked in potash duckweed meals (Sogbesan *et al.,* 2015). The low WG and SGR as well as the variations could be due to the treatment methods used for duckweed preparations. Facts have been adduced that proteins in ingredients can be denatured by the kind of methods used in processing them before incorporatin into feed formulations (Fasakin *et al.,* 2001; Sogbesan *et al.,* 2015). The SGR was similar to reported values 0.98g/day by Hassan *et al.,* (2019) when silver carp was fed DWM and rice bran diet, in which it led to improved production of carp. Herawati *et al.,* (2020) fermented duckweed and replaced it with soybean. Their study revealed that 2.5% of fermented DWM performed best while 5% and 7.5% also better in performance over the soybean control diet, as fermentation improved the quality of DWM in diet formulation. Also, in this study processing improved nutritional content of DWM, which however did not translate to improved growth. The reason for which can be environmental in nature, culture medium from which the duckweed was collected, nutrient load of the culture medium and processing by cooking and soaking which can affect some of the nutrients in the test ingredient. The percentage survival of the experimental fish in this study was favourable and did not deviate from range of those reported by Sogbesan *et al.,* (2015) (75 to 92) for *C. gariepinus* and were also comparable to Asimi *et al.,* (2018) and Yilmaz *et al.* (2004), for common carp (*Cyrinus carpio*) fed with graded levels of raw duckweed meal diets.

Nutrients utilization of Nile tilapia (*O. niloticus*) juveniles fed raw and treated duckweed (*L. minor*) meals-based diets

The results obtained for FCR was comparable to Sogbesan *et al.,* (2015), who reported FCR range between 2.37 to 3.06. Similarly, Asimi *et al.,* (2018) and Yilmaz *et al.,* (2004) also reported FCR ranges between 2.41 and 2.95 in feeding trial involving supplemental levels of duckweed in the diets of *C. carpio* fingerling and fry, respectively. However, the FCR results obtained in the present study contravened the works of Fasakin *et al.,* (1999) who reported progressive reduction in growth performance and nutrients utilization when duckweed meal was incorporated at progressively increased levels in experimental diets of fish above 20%. Samnang (1999) and Patra (2015) had also reported decreased growth of chicken and *Labeo rohita* due to gradual increase in duckweed meal inclusion levels in practical diets as fish meal and soybean meal, respectively. The current research revealed no growth and nutrients performance differences of experimental fish fed control, raw and treated duckweed meal supplemented diets. This was also noticed by Fasakin *et al.,* (1999) when fish was fed duckweed supplemented diets at 0% to 20% inclusion levels. Pagliuso *et al.,* (2022) stated that due to the combination of different nutrients duckweed can be used in meeting nutritional needs of the world. The NPU values obtained in this study for raw and treatment methods and at all levels of inclusion were comparable to the result obtained for 10% inclusion level of duckweed in the experimental diet of *O. niloticus* raised in outdoor hapa cages by Solomon and Okomoda (2012), higher than those recorded for other inclusion levels. The results variation of the present study and the cited authors could be due to differences in culture environment and experimental design. However, the values obtained for PER and PPV in this study were at great variance from those reported by authors. Sogbesan *et al.,* (2015) recorded PER between 0.2 and 0.6 for catfish and Yilmaz *et al.,* (2004) from 1.35 to 1.67 for *C. carpio*. Generally, the values of the growth and nutrients utilization parameters obtained for raw and treated duckweed meal supplemented diets at all levels of supplementation in this study were not inferior to the control experiment. This study supports Méndez-Martínez *et al.,* (2021) that DWM was used for growth optimally up to 12% in the diet of *C. gariepinus.*

Haematological response of Nile tilapia (*O. niloticus)* fed raw and treated duckweed (*L. minor*) meals-based diets

Heamatological analysis and blood chemistry are valuable tools and determinants of metabolic disturbances and disease conditions in fish (Celik *et al.,* 2004). Hematological markers are diagnostic tools for detecting possible nutritional effects on the health of aquatic animals (Burgos-Aceves *et al.,* 2019; Dawood *et al.,* 2016; Dawood *et al.,* 2019; Dawood *et al.,* 2020; Faggio *et al.,* 2014a; 2014b). Fish nutritional status is an important variable that can alter blood values of experimental fish (Congleton and Wagner, 2006), while Banerjee *et al.,* (2002) reported that blood composition is moderately constant with little variation above limits under normal condition, but may be changed due to dietary treatment, malnutrition and disease condition (Feist and Longshaw, 2000).

In the study, haematological parameters examined were used to evaluate the general well-being of the experimental fish. The values of PCV, haemoglobin, and MCV of the experimental fish (*O. niloticus*) fed raw and treated duckweed (*L. minor*) supplemented diets were not greatly affected by treatment methods and inclusion levels as these values were not statistically different from the control experiment and were not inferior to the values reported by Osuigwe *et al.,* (2005) and Sotolu and Faturoti (2008). The haematology parameters measured in the current study showed stable and normal values, revealing the non-noxious effect of duckweed (*L. minor*) inclusion in the diets tilapia (*O. niloticus*). The RBC values obtained in this experiment were comparable to the control and indicated that the experimental fish were free of anemia as a result of feeding on the raw and treated duckweed supplemented diets. Similar result was documented by Magouz *et al.,* (2020) when genetically-improved farm tilapia was fed with Azolla (*Azolla pinnata*) supplemented diets. The RBC in Co treatment and MCH at 15% inclusion similar to 1.66($\times 10^6$ µl) and 52.98(pg) for *H. molitrix* fed with DWM in comparison with *Glycine max* in monoculture and polyculture system for small fingerlings (Aslam *et al.,* 2021), respectively. However, difference noted in this study with Irabor *et al.,* (2022) can be adduced to species difference, ingredient supplemented and higher inclusion levels of DWM in the diet above this study; although no effect was also noticed on the experimental fish.

CONCLUSION

This study revealed that utilization of soybean feed resulted in superior performance over Raw and treated duckweed (*Lemna minor*) meals as replacement for soybean in diets of tilapia. Hence, research on locally adaptable processing methods that will lead to increase use of duckweed by local fish farmers as fish feed ingredient alternatives is hereby advocated to reduce soybean inclusion in feed and increase utilization of DWM.

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