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Apparent Nutrient Digestibility Coefficient of Solid State Fermented Plam Kernel Sludge Fed to *Clarias gariepinus*

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Abstract
This study assessed apparent digestibility coefficient for Dry Matter (DM) Crude Protein (CP), Crude Fibre (CF) and energy of solid state fermented Palm Kernel Sludge(PKS) in diets of *Clarias gariepinus* juveniles for 56 days.Experimental diets were composed of 70% reference diet and 30% test ingredient with chromic oxide as marker. Test ingredients were *Aspergilluscandidus* fermented PKS (AcfPKS), *Aspergillusflavus* fermented PKS(AffPKS), *Aspergillusniger* fermented PKS(AnfPKS), *Rhizopusmicrospororus* fermented PKS (RmfPKS), *Trichodermaharzianum* fermented PKS (ThfPKS), *Aspergillusbrasiliensis* fermented PKS(AbfPKS), *Phythium* sp. fermented PKS (PsfPKS) and *Cunnighamela* sp. fermented PKS (CsfPKS).It was observed that AcfPKShad the highest digestibility coefficients in terms of DM (93.79±4.06%), CP (94.37±1.84%), CF(97.42±1.39%), oil (89.09±1.16%), ash (83.10±83.10%), nitrogen free extract (NFE) (102.25±6.98%) and Gross energy (93.11±3.67%), this was followed by PsfPKS> AbfPKS> AnfPKS, >AffPKS and ThfPKS.Negative digestibility coefficients were observed in CsfPKS and RmfPKS for ash (-13.71±24.32%, - 4.20±14.26%) and NFE (-5.71±10.30%, -18.36±27.54%) respectively. The study reports that *Clarias gariepinus* juveniles can digest PKS that has undergone solid state fermentation with fungi.

Keywords:negative digestibility coefficient, catfish, *Aspergillus*, palm kernel sludge

Introduction

Agro-waste from oil palm production in Nigeria has nutritive value which can be used in aquaculture after digestibility, using fungi in solid state fermentation (SSF).Nutrient digestibilities of feed ingredients could result into favourable substitution of feed ingredients without reducing animal performance (Borghesi *et al*., 2008).Results of digestibility coefficient evaluation make it possible to accurately estimate the composition of each ingredient in fish feed as well as quantity of feed wastes and undigested nutrients that may potentially accumulate in fish ponds (Kenan and Ozdemir, 2005).The digestibility of a nutrient is expected to be a positive integer and within 1-100, however this may be contrary in reality and negative values may be obtained as well as values greater than 100%.

Thus, the aim of this study was to assess apparent digestibility coefficient for protein, fibre and energy of solid state fermented palm kernel sludge in diets of *Clarias gariepinus* juveniles.

Materials and Methods

A digestibility (acceptability) assay was carried out on catfish juveniles using solid state fermented palm kernel sludge (PKS). Eight fungal isolates from the sludge were used to produce crude enzyme extract using solid state fermentation process. The crude enzyme extract was used to degrade PKS for seven days,which was later incorporated into formulated experimental diets.Also, test fish of average weight, standard length (SL) and total length (TL) (15.81±0.77g), (11.38±0.70cm) and (12.77±0.75cm) respectively,were procured from a commercial fish farm in Ibadan,acclimatisedin 35L rectangular plastic aquariumsfor two weeks and fed commercial diets(2 mm, Skretting feed).After acclimitization, the fish were fed dietscontaining 30% of the fermented PKS for eight weeks(De Silva and Anderson, 1995). Chromic oxide (Cr_2O_3)was included as exogenous marker at 0.5% inclusion (NRC, 1993). Rectangular plastic aquariums were used to rear the fish. The experiment was made up of nine treatments consisting of one reference diet and eight other diets that contained test ingredients. Formulated reference diet contained 40% crude protein. All the treatments werein triplicates. Each treatment was stocked withforty-two (42) fish withfourteen (14) fish per replicate.

The average weight, standard length (SL) and total length (TL) of fish used were: (15.81±0.77g), (11.38±0.70cm) and (12.77±0.75cm) respectively. The fish were fed at 5% of their body weight daily and the feed was adjusted every forthnight.Thetest ingredientsused for the experimentwere: *Aspergilluscandidus*fermented PKS (AcfPKS), *Aspergillusflavus* fermented PKS(AffPKS), *Aspergillusniger* fermented PKS(AnfPKS), *Rhizopusmicrospororus* fermented PKS (RmfPKS), *Trichodermaharzianum* fermented

PKS (ThfPKS),*Aspergillusbrasiliensis* fermented PKS(AbfPKS), *Phythium* sp. fermented PKS (PsfPKS) and *Cunnighamela* sp. fermented PKS (CsfPKS).

The fish were fed for two weeks with experimental diet to introduce them to mock faecal collection (De Silva and Anderson, 1995). Thereafter, faecal samples were collected after every three days. The faeceswere collected by changing the water of the rearing plastic tank early in the morning after which,mild pressure was applied on the lower abdomen of the fish. The faeces were spread on a labelled sheet of paper and sun dried. The sun dried faeces were stored in a universal sample bottle and stored in a cool dry place. Subsequent faecal samples collected were added to the composite sample until the eighth week when enough quantity (7-10g) of dry faeces were collected. Apparent digestibility coefficient of DM, CP, CF and energy values in each diet were determined using Cr_2O_3 as marker. Chromic oxide in diets and faeces was analyzed using the method of Furukawa and Tsukahara (1966) as modified by Olvera-Novoa *et al.*, (1994).

The nutrients and energy values in the diets and faeces were used to calculate apparent digestibility coefficients (ADC) using the formulae:

$$\text{Drymatter digestibility (\%)} = 100 - (100\ \text{X}\ (\frac{\%\text{Cr}_2\text{O}_3\ \text{in diet}}{\%\text{Cr}_2\text{O}_3 \text{in feed}}))$$

$$\text{Nutrient Digestibility (\%)} = 100 - (100\ \text{X}\ (\frac{\%\text{Cr}_2\text{O}_3\ \text{in diet}}{\%\text{Cr}_2\text{O}_3 \text{in faeces}})\ \text{X}\ (\frac{\%\ \text{Nutrient in faeces}}{\%\ \text{Nutrient in diet}}))$$

The ADCs for dry matter, crude protein, crude lipid and energy were calculated from the respective digestibility coefficients for the Reference Diet (RD) and Test Diet (TD) on the basis of the 30% substitution of test ingredient in the reference diet (Cho *et al.*, 1982) using the formulae of De Silva and Anderson (1995)

$$Apparent\ total\ digestibility\ of\ the\ ingredient = \frac{100}{30}(dry\ matter\ digestibility\ \ of\ TD - \frac{70}{100} dry\ matter\ digestibility\ of\ RD)$$

$$Apparent\ nutrient\ digestibility\ of\ the\ ingredient = \frac{100}{30}\left(nutrient\ digestibility\ \ of\ TD - \frac{70}{100} nutrient\ digestibility\ of\ RD\right)$$

Results and Discussion

Apparent total digestibilitycoefficient is presented in Table 1while apparent nutrient digestibility coefficient is presented in Table 2.Apparent total digestibility coefficient of the diet revealed that all the diets had high digestibility for all nutrients ranging from 97.04±0.09% (CP, Control) to 53.22±8.27% (NFE, RmfPKS). However, the apparent nutrient digestibility coefficient showed that AcfPKShad the highest digestibility in terms Dry Matter (DM) (93.79±4.06%), Crude Protein (CP) (94.37±1.84%), Crude Fibre (CF) (97.42±1.39%), oil (89.09±1.16%), ash (83.10±83.10%), NFE (102.25±6.98%) and Gross energy (93.11±3.67%), this was followed by PsfPKS, AbfPKS, AnfPKS, AffPKS and ThfPKS.High digestibility of protein recorded in this study is in line with report of Sullivan and Reigh (1996) as cited by McGoogan and Reigh (1996) that feed ingredients of plant origin do not contain levels of protein as high as those in ingredients of animal origin but protein in many plant products appears to be digested as efficiently as carnivorous and omnivorous fishes as that in animal products.It is also in line with report of Pillay(1990)who noted that digestibilityof most natural proteins and lipids rangedfrom 80-90 percent whereas indigestiblematerials were eventually voided as faeces

Low digestibility coefficients for DM (16.45±8.53%, 14.99±17.49%), CP (53.22±5.13%, 57.73±8.31%), CF (66.94±4.49%, 62.42±10.54%), oil (9.67±17.29%, 25.02±6.06%), ash (-13.71±24.32%, -4.20±14.26%), NFE (-5.71±10.30%, -18.36±27.54%) and gross energy (15.51±9.06%, 15.89±16.45%) were observed for CsfPKS and RmfPKS respectively. Physiologically, ADCs should range between 0% and 100% butin this study, negative values and values greater than 100% were observed. According to Sugiura *et al.* (2000), negative availability values are due to interactions between the test ingredient and basal (reference) diet. However, the negative value does not indicate a negative balance of nutrients, but an antagonistic property of the test ingredient for the absorption of nutrients in diets (Guimarães *et al*., 2012). Also, ADC values greater than 100% have been reported to be due to interactions among nutrients (Brunson *et al*., 1997) or high temperatures that are sometimes used duringmanufacturing processes of feed ingredients (Chen *et al.*, 2016).

Conclusion

This study concludes that PKS that has undergone solid state fermentation using fungal spores can be digested by*Clariasgariepinus*juveniles.

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Table 1.Apparent dry matter/total digestibility coefficient of SSF-PKS in diet of *Clariasgariepinus*

ParameterDM (%)	CP (%)		CF (%)	Oil (%)	Ash (%)	NFE (%)	Gross Energy (%)
Crude enzyme extract							
Control	92.09±0.12^{a}	97.04±0.09^{a}	96.48±0.78^{a}	94.41±0.57^{a}	94.04±0.24^{a}	84.76±0.30^{ab}	92.39±0.04^{a}
ThfPKS	71.43±4.45^{de}	85.36±1.70^{fg}	87.21±4.12^{c}	77.05±4.82^{bc}	69.05±1.15^{efg}	58.84±6.64^{de}	71.87±4.29^{de}
CsfPKS	69.40±2.56^{e}	83.90±1.54^{g}	87.61±1.34^{c}	69.84±5.19^{c}	61.72±7.30^{g}	57.01±3.09^{de}	69.45±2.72^{e}
AcfPKS	92.60±1.22^{a}	96.24±0.55^{ab}	96.75±0.42^{a}	93.79±0.34^{a}	90.76±1.86^{ab}	89.40±2.09^{a}	92.73±1.10^{a}
PsfPKS	89.00±2.81^{ab}	94.60±1.17^{abc}	95.75±1.39^{a}	90.57±1.32^{a}	87.68±3.34^{abc}	83.61±4.18^{ab}	89.06±2.63^{ab}
RmfPKS	68.96±5.25^{e}	85.25±2.49^{fg}	86.26±3.16^{c}	74.56±1.82^{bc}	64.57±4.58^{fg}	53.22±8.27^{e}	69.57±4.94^{e}
AbfPKS	87.81±0.00^{ab}	94.26±0.30^{abc}	94.41±0.25^{ab}	90.40±0.95^{a}	85.37±0.31^{abc}	81.98±0.42^{ab}	88.20±0.13^{ab}
AffPKS	83.53±1.61^{bc}	91.75±0.94^{cd}	93.63±1.07^{ab}	88.91±1.80^{a}	79.46±1.82^{bcde}	75.35±2.53^{bc}	83.89±1.73^{bc}
AnfPKS	85.39±2.81^{ab}	93.17±1.28^{bcd}	94.16±1.61^{ab}	87.47±2.64^{a}	82.67±5.14^{bcd}	77.65±4.64^{abc}	85.49±2.71^{ab}

NB: Values with the same superscript in each column are not significant (p>0.05) at 5% level of probability

Table2.Apparent nutrient digestibility coefficient of SSF-PKS in the diet of *Clariasgariepinus*

Parameter DM(%)	CP(%)	CF(%)	Oil(%)	Ash(%)	NFE(%)	Gross Energy
Crude enzyme extract						
ThfPKS	23.22±14.42^{def}	58.08±5.66^{ef}	65.60±13.75^{c}	33.31±16.05^{bc}	10.73±3.85^{de}	0.37±22.13^{de}	23.55±14.29^{def}
CsfPKS	16.45± 8.53^{ef}	53.22±5.13^{f}	66.94± 4.49^{c}	9.67±17.29^{cd}	-13.71±24.32^{e}	-5.71±10.30^{de}	15.51±9.06^{ef}
AcfPKS	93.79± 4.06^{a}	94.37±1.86^{a}	97.42± 1.39^{a}	89.09±1.16^{a}	83.10± 6.19^{a}	102.25±6.98^{a}	93.11±3.67^{a}
PsfPKS	81.79± 9.40^{ab}	88.88±3.92^{ab}	94.07± 4.63^{a}	78.37±4.42^{a}	72.84±11.15^{ab}	82.92±13.93^{ab}	80.86±8.77^{ab}
RmfPKS	14.99±17.49^{ef}	57.73±8.31^{ef}	62.42±10.54^{c}	25.02±6.06^{bcd}	-4.20±14.26^{e}	-18.36±27.54^{e}	15.89±16.45^{ef}
AbfPKS	77.85± 0.00^{ab}	87.76±0.99^{ab}	89.59± 0.82^{ab}	77.80±3.14^{a}	65.12±1.02^{ab}	77.50±1.42^{ab}	77.99±0.43^{ab}
AffPKS	63.57± 5.34^{bc}	79.42±3.14^{bc}	87.02± 3.57^{ab}	72.81±6.01^{a}	45.43±6.07^{abcd}	55.41±8.43^{bc}	63.62±5.78^{bc}
AnfPKS	69.77± 9.36^{ab}	84.13±4.27^{abc}	88.75± 5.40^{ab}	68.04±8.81^{a}	56.12±17.18^{abc}	63.06±15.47^{abc}	68.98±9.04^{ab}

NB: Values with the same superscript in each column are not significant (p>0.05) at 5% level of probability