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Evaluation of Protein Replacement Value of Sun Dried and Oven Dried Coconut Oil Meal and Fermented Coconut Oil Meal in Rats

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Abstract: Twenty-four male albino rats, Wistar's strain of 21-22 days old, with average weight of 27.6-27.9 g were fed sun dried coconut oil meal (SDCOM), oven dried coconut oil meal (ODCOM), sun dried fermented coconut oil meal (SDFCOM) and oven dried fermented coconut oil meal (ODFCOM) to evaluate the protein quality indices using a nitrogen free diet and casein nitrogen based diet as reference. The feed intake (FI), protein intake (PI) and faecal nitrogen were all significantly ($p<0.05$) higher in the reference diet and SDFCOM. The body weight gain in the reference diet was significantly ($p<0.05$) higher than the others but followed by values recorded by rats on SDFCOM and ODFCOM. Urinary nitrogen was highest in ($p<0.05$) in SDCOM. The nitrogen retained was higher ($p<0.05$) for rats fed SDFCOM and ODFCOM. Apparent Digestibilities of Nitrogen (AND) were similar for the reference diet, SDFCOM and ODFCOM. The True Protein Digestibility (TPD), Biological Value (BV), Protein Efficiency Ratio (PER), Net Protein Utilization (NPU) and Net Protein Ratio (NPR) were all highest in the reference diet and followed by ODFCOM and lowest in SDCOM while the gross protein value (GPV) was highest ($p<0.05$) for rats on ODFCOM. The TPD and GPV were strongly correlated ($Y = 5.716x-267.07$) with $R^2 = 0.98$. Amino acids values for the four samples were similar but leucine was highest in ODCOM. The determined values of mineral composition for SDCOM, ODCOM, SDFCOM and ODFCOM were also very similar, but phosphorous had the highest coefficient of variation (24.26%) followed by Ca, K, Zn, Mn, Mg and Cu. Oven dried fermented sample of coconut oil meal (ODFCOM) exhibited better protein quality index values than the others sun dried.

Key words: Coconut oil meal, drying, fermentation, protein quality

Introduction

Legumes and oil seed cakes forms the main sources of vegetable proteins in the formulation of animal feeds. Notable among these include soybeans and groundnut cake which are very expensive as a result of their use in human foods. Therefore, animal nutritionists are inadvertently faced with the challenges of finding alternatives to plant protein sources, to reduce the pressure on the hitherto expensive oil seed cakes. Among the relatively cheap sources of vegetable proteins that belong to the oil seeds group is coconut oil meal. Coconut oil meal (COM) is the residue obtained after the extraction of coconut oil from the coconut meat fruits of *cocos nucifera* while fermented coconut oil meal was the product of fermentation of the COM. Variation in the quality of the vegetable proteins has direct proportionality to their respective cost and production efficiency. Several workers had reported low feed intake and poor weight gain when coconut oil meal is included in the ration of livestock especially poultry (Armas and Chicco, 1977; Ochetim, 1987; Panigrahi, 1992; Baidya *et al*., 1995; Dairo and Ogunmodede, 2000). Teve *et al*. (1992) indicated fibre as the major impedance to the adequate utilization of coconut oil meal and reported an improvement in feed consumption, weight gain and efficiency of feed utilization when treated with mannase enzyme. The measurement of protein quality of feed stuffs using rat assay is an important procedure to ascertain the nutritive value of ingredients for a better

informed application of the principles derived from the investigations in practical feed formulation. This is for optimum utilization especially in developing countries where the high quality vegetable protein sources are very expensive. Coconut oil meal and fermented coconut oil meal are not popular vegetable protein sources for poultry in Nigeria even in the coastal area of the south western part where it is common. It is fed to pigs and small ruminants that scavenge either in the fresh forms or heaped up in a place where fermentation often set in. The abundance of coconut fruits in the coastal stretch of Nigeria and the relatively lower cost when compared with groundnut cake or soybean meal motivated this study of the effect of drying process on the replacement value of coconut oil meal and fermented coconut oil meal in a form in which they may be available for farmers and feed millers.

Materials and Methods

Preparation of Experimental Diets

Coconut oil meal residue was collected wet in a feed grade bag from the cottage processing industry for coconut oil extraction. The bags were tied tightly at the mouth and locally fabricated hydraulic press was used to press out the water content. The residue was divided into two equal parts. One part was allowed to ferment for a period of three days by covering with black polythene sheet in an open sided shed at ambient temperature of 25.8°C and averaged relative humidity of 83.2%. The fermented portion was again divided into two halves. The first half was sun dried to crispy touch and called sun dried fermented coconut oil meal (SDFCOM) while the second half was oven dried at 65°C in a Gallenkamp oven for 36 h and called oven dried fermented coconut oil meal (ODFCOM). The unfermented fresh coconut oil meal called COM was also divided into two equal portions. The first half was sun dried to a moisture content of about 12%, good for storage of feed materials and called sun dried coconut oil meal (SDCOM) while the other half was oven dried in the same oven described above for 36 h also and labelled oven dried coconut oil meal (ODCOM). Enough quantity of SDCOM, ODCOM, SDFCOM and ODFCOM for the preparation of rat diets were taken and ground in Christy and Norris Portable Laboratory mill. The milled portions of these test ingredients were then used to prepare four separate 10% crude protein test diets in which they were the main source of protein. Two other diets were prepared. The first was formulated so that it supplied no nitrogen to the rats while nutritional casein was used as the main source of nitrogen for the second which represented the reference diet. This gave a total of six diets in all. The test ingredients were used at the expense of corn starch (Table 1).

Table 1: Composition of experimental diets (%)

Ingredients/Diets	A	B	C	D	E	F
Casein	-	10.82	-	-	-	-
Corn starch	63.00	52.18	16.40	22.22	22.85	24.28
Glucose	5.00	5.00	5.00	5.00	5.00	5.00
Sucrose	10.00	10.00	10.00	10.00	10.00	10.00
Corn cob	5.00	5.00	5.00	5.00	5.00	5.00
Groundnut oil	10.00	10.00	10.00	10.00	10.00	10.00
Bone meal	2.25	2.50	2.50	2.50	2.50	2.50
Vit* Premix	4.00	4.00	4.00	4.00	4.00	4.00
Salt	0.50	0.50	0.50	0.50	0.50	0.50
SDCOM	-	-	50.9	-	-	-
ODCOM	-	-	-	45.08	-	-
SDFCOM	-	-	-	-	44.45	-
ODFCOM	-	-	-	-	-	43.02
	100.00	100.00	100.00	100.00	100.00	100.00
Chemical analysis						
Dry matter	96.70	97.11	96.85	96.65	97.01	96.83
Crude protein	10.10	10.02	10.00	10.01	10.08	10.10
Crude fibre	5.81	6.01	6.15	6.11	6.20	6.22
Ether extract	10.20	14.03	14.51	14.29	14.30	14.42
Ash	0.88	1.18	1.25	1.20	1.19	1.23
M.E. (Calc.) MJ/kg	12.80	12.91	12.77	12.89	12.81	12.92

Site Preparation

The study was carried out at the Teaching and Research Farms of the Lagos State Polytechnic Ikorodu in Nigeria. The rat cages were thoroughly washed and disinfected using a phenol based disinfectant solution. The open sided experimental pen was dusted and washed with same disinfectant. The house was then allowed to rest for seven days before the commencement of the study.

Experimental Procedure and Animal Management

Twenty-four male albino rats of 21-22 days old with weight 27.6-27.9 g of Wistar strain were used for the study. They were randomly divided into six groups, balanced for weight and individually housed in cages with facilities for the collection of urine and faeces. They were fed standard rat diets for Laboratory animals for a period of 3 days before the commencement of the experiment. Each of the six groups of rat were weighed individually and fed on the experimental diets for a period of 12 days. Group A was fed on the nitrogen free diet, B on the reference diet, C on the diet where SDCOM was the main source of protein and D on diet where ODCOM supplied the protein, E represent the diet where SDFCOM was used and diet F contained ODFCOM as the main source of protein. Daily records of the feed intake were measured by subtracting the weight value of the air dried feed remnant and spilled from the initial values. The body weights were measured by difference of the final weight from the initial values for the period of the study. A five day collection period was used for the urine and faeces on daily basis. The urine from each rat was collected in a small glass bottle container while faeces was collected on aluminum foil paper, weighed wet and stored at -5°C in an aluminum foil paper. At the end of the collection period, the faecal samples were bulked and dried at 60°C for 36 h in a Gallenkamp oven. It was later weighed ground and stored in screw-capped sample bottles prior to analysis. The urine and faecal samples were then analyzed for nitrogen as described by AOAC (1995) and the values obtained used for the computation of the protein quality indices from nitrogen intake and nitrogen voided as follows:

Nitrogen Retained (NR) was obtained by the difference of the nitrogen intake (NI) and the sum of the nitrogen voided in the faeces (FN) and the urine (UN) i.e.,

$$NR = NI - (FN+UN)$$

Apparent Digestibility of Nitrogen (AND) was computed as the percentage of the ratio of the nitrogen retained to the nitrogen intake i.e., $AND = NI - (FN+UN)/ NI \times 100$.

True Digestibility (TD) as the percent ratio of the NI minus the sum of the FN and metabolic nitrogen (MN) i.e., $TD = NI - (FN-MN)/ NI \times 100$

Biological value (BV) = NI – (FN – MN) - UN/ NI – (FN –MN)

$$\text{Net Proptein Utilization (NPU)} = \frac{\text{Body N of test group} - \text{Body N of protein group}}{\text{Nitrogen consumed by test group}} \times \frac{100}{1}$$

$$\text{Net Protein Ratio (NPR)} = \frac{\text{Gain in wt. group on test diet} - \text{wt. loss of group on protein free diet}}{\text{Protein consumed}} \times \frac{100}{1}$$

$$\text{Gross Protein Value (GPV)} = \frac{\text{Gram increased weight per gram test protein}}{\text{Gram increased weight per gram casein}} \times \frac{100}{1}$$

Chemical Analysis and Statistical Tool

Amino Acids Analysis

About 60 mg each of the differently processed and dried coconut oil meal samples was hydrolyzed in a screw-capped glass hydrolyzing tube for the determination of the amino acids

constituents. Each of the tube containing SDCOM, ODCOM, SDFCOM and ODFCOM were placed (at various times) on a previously heated block with temperature of 110°C and refluxed for 24 h. Each of the hydrolysate was then cooled and transferred to a 50 mL flask. This was then diluted to volume with water in the flask and filtered. A 10 mL aliquot of the filtrate was here after heated in a rotatory evaporator at about 40°C to remove the excess acid. The aliquot was then analysed using HLPC Autosampler (konton 460). Methionine was determined as methionine sulphone and cysteine as cysteic acid. Tryptophan was also determined as described by Miller (1967). DL-Amino-n-butyric acid was used as internal standard to correct for the slight fluctuation in the amino acid peaks. The SDCOM, ODCOM, SDFCOM, ODFCOM and the experimental diets were analyzed for proximate composition by the method of AOAC (1995). Mineral analysis were determined after wet digestion of each of the samples using a mixture of nitric, sulphuric and hydrochloric acids, The sodium and potassium content of the samples were carried out using the Flame photometric method while vanadomolybdate procedure was used to determine phosphorus.

All the data obtained were subjected to one way analysis of variance using SAS (1987) statistical package.

Results and Discussion

The performance of the rats on the experimental diets and nutritive value of coconut oil meal and fermented coconut oil meal is presented in Table 2. The group of rats on the casein diet (Diet B) and those on fermented coconut oil meal (Diet E) had significantly higher values ($p<0.05$) for feed intake (66.40±1.05 and 68.29±1.39 g), protein intake (6.67±0.1 and 6.83±0.13 g), nitrogen intake (1.07±0.02 and 1.09±0.02 g), faecal nitrogen (0.35±0.01 and 0.36±0.02 g), while those on diet C had significantly ($p<0.05$) higher urinary nitrogen (0.23±0.01 g). Rats fed diet B had the highest body weight gain (16.57±0.22 g) than the others ($p<0.05$). The protein quality measurement is shown in Table 3. All the indices measured had values that were significantly higher ($p<0.05$) than those obtained for the test ingredients. However, t he GPV was highest ($p<0.05$) for rats fed ODFCOM (69.16±0.11). The mineral composition of the test ingredients is presented in Table 4. Calcium (Ca) had a range of 0.17-0.23% with the value obtained in ODFCOM as the highest and coefficient of

Table 2: Performance of rats fed sun dried, fermented and oven dried coconut oil meal

Parameters/Diets	A	B	C	D	E	F	SEM
Feed intake (g)	55.11±3.05^{d}	66.40±1.05^{a}	60.21±0.67^{c}	64.22±0.72^{b}	68.29±1.39^{a}	64.19±1.2^{b}	1.19
Body weight gain (g)	2.91±0.49^{e}	16.57±0.22^{a}	9.05±0.13^{d}	9.98±0.01^{c}	10.92±1.56^{b}	11.46±0.8^{b}	0.73
Protein intake (g)	5.51±0.31^{e}	6.67±0.10^{a}	6.02±0.07^{d}	6.57±0.02^{c}	6.83±0.13^{a}	6.43±0.04^{b}	0.12
Nitrogen intake (g)	0.88±0.05^{d}	1.07±0.017^{a}	0.96±0.01^{c}	1.03±0.01^{b}	1.09±0.02^{a}	1.03±0.03^{b}	0.039
Faecal nitrogen (g)	0.16±0.01^{d}	0.33±0.01^{a}	0.19±0.01^{c}	0.32±0.01^{b}	0.36±0.02^{a}	0.36±0.02^{a}	0.011
Urinarynitrogen (g)	0.092±0.005^{d}	0.093±0.01^{d}	0.23±0.04^{a}	0.12±0.001^{c}	0.19±0.018^{b}	0.095±0.001^{d}	0.005

Means with different superscript on the same row differ significantly ($p<0.05$)

Table 3: Some protein quality indices of sun dried, fermented and oven dried coconut oil meals

Parameters/Diets	B	C	D	E	F	SEM
Nitrogen Retained (NR) (g)	0.66±0.01^{a}	0.544±0.008^{d}	0.59±0.02^{c}	0.63±0.09^{b}	0.645±0.07^{b}	0.001
Apparent Digestibility of Nitrogen (ADN) (%)	58.49±0.21^{a}	56.25±0.11^{b}	57.28±0.02^{c}	58.44±0.39^{a}	58.64±0.01^{a}	0.03
True Digestibility of Protein (TDP) (%)	79.40±0.43^{a}	59.30±0.48^{e}	59.91±0.21^{d}	59.96±0.77^{c}	62.03±0.62^{b}	0.49
Biological Value (BV) (%)	64.99±0.91^{a}	55.78±0.89^{e}	57.32±0.48^{d}	60.52±0.57^{c}	63.47±0.11^{b}	1.35
Protein Efficiency Ratio (PER)	2.50±0.04^{a}	1.50±0.03^{c}	1.52±0.02^{c}	1.59±0.20^{b}	1.65±0.03^{b}	0.108
Net Protein Utilization (NPU)	51.60±1.09^{a}	33.08±0.40^{d}	34.34±0.26^{cd}	36.61±0.34^{c}	39.37±0.22^{b}	2.45
Net Protein Ratio(NPR)	2.06±0.10^{a}	1.02±0.06^{e}	1.84±0.02^{d}	1.60±0.27^{c}	1.23±0.12^{b}	0.12
Gross Protein Value (GPV)	-	54.62±0.41^{d}	60.22±0.03^{c}	65.90±0.82^{b}	69.16±0.11^{a}	3.08

Means with different superscript on the same row differ significantly ($p<0.05$)

Table 4: Some mineral content of sun dried, fermented and oven dried coconut oil meals (%)

Diets	Ca	Mg	Zn	K	Mn	Cu	P
C(SDCOM)	0.17	0.21	0.57	1.56	0.81	0.74	0.61
D (ODCOM)	0.21	0.20	0.56	1.27	0.85	0.80	0.72
E(SDFCOM)	0.19	0.19	0.53	1.75	0.75	0.77	0.55
F (ODCOM)	0.23	0.18	0.45	1/54	0.69	0.71	0.39
CV*	12.91	6.62	10.31	12.91	9.03	5.13	24.26

CV* = Coefficient of variation

Table 5: Amino acid composition of sun dried, fermented and oven dried coconut oil meals (mg g^{-1})

Amino acids	Sun dried coconut oil meal (SDCOM)	Oven dried coconut oil meal(ODCOM)	Sun dried fermented coconut oil meal (SDFCOM)	Oven dried fermented coconut oil meal (ODFCOM)	Coefficient of variation (CV)
Arginine	2.01	2.07	2.07	2.06	1.28
Cystine	0.21	0.22	0.22	0.23	5.74
Histidine	0.39	0.26	0.26	0.36	16.47
Isoleucine	0.59	0.60	0.60	0.58	2.93
Leucine	1.18	1.23	1.20	1.31	28.74
Lysine	0.51	0.52	0.53	0.52	3.33
Methionine	0.35	0.37	0.38	0.37	3.42
Phenylalnine	0.80	0.82	0.82	0.80	2.59
Threonine	0.61	0.61	0.61	0.62	1.32
Tryptophane	0.06	0.06	0.06	0.06	5.13
Tyrosine	0.44	0.39	0.39	0.04	94.60
Valine	0.89	0.75	0.75	0.77	59.84
Alanine	0.79	0.52	0.52	0.71	17.65
Aspartic acid	1.59	0.98	0.98	1.65	21.56
Glutamic acid	3.64	3.38	3.38	3.28	8.21
Gycine	0.90	0.99	0.99	0.83	6.67
Serine	0.96	0.83	0.83	0.97	7.55

variation (CV) of 12.91%. Coconut oil meal had the highest values of magnesium (Mg) and zinc (Zn) with a range of 0.18-0.21, 6.62% as CV and 0.45-0.57% with 10.31% as CV, respectively. Potassium (K) content of the test materials ranged between 1.27-1.75% and CV of 12.91% with SDFCOM having the highest value. Manganese (Mn) content ranged between 0.69-0.85% with CV 9.03% and the highest value recorded in ODCOM. Copper (Cu) and phosphorous (P) contents of the test ingredients were recorded in ODFCOM (0.71%) and ODCOM (0.39%) with 5.13 and 24.26% as their respective CV. The values ranged between 0.71-0.80% for copper and 0.39-0.72% for phosphorous and ODCOM had the highest content of Cu and P. The effect of processing on the amino acids composition of the test materials varies (Table 5). Tyrosine, valine, alanine and aspartic acids were profoundly affected by the processing technique with coefficient of variations 94.4, 59.84, 17.65 and 21.56%, respectively. The feed intake of the rats on reference diet (i.e., diet B) and those on SDFCOM (diet E) were similar. The fermentation of the coconut oil meal obviously improved the nutrient levels of SDFCOM as the crude protein content increased from 19.63 to 22.48% which also agreed with the reports of other workers (Yang *et al*., 1993; Balagopalan, 1996; Abu *et al*., 1997; Dairo and Ogunmodede, 2000). This might have improved the intake of the rats as a result of the microbial actions on the cell wall components of SDCOM and the presence of the microbes themselves as a source of animal protein with a consequential upgrading of some of the essential amino acids profile of SDFCOM such as histidine, lysine methionine, leucine and isoleucine. The body weight gain almost followed the same pattern of the feed intake which expectedly reflected in the protein and nitrogen intake of rats on these diets. Urinary nitrogen was highest for rats on SDCOM indicating wastage of the protein (Eggum, 1976). Interestingly, rats fed diets containing SDFCOM also indicated this phenomenon of wastage but at a lower level than SDCOM. This appeared contrary to expectation because the presence of the microbes ought to have improved the quality of SDFCOM proteins. However since the fermentation was not substrate specific and the aflatoxin level in the SDFCOM not determined it is not impossible to observe this effect (Roussas *et al*., 1994; Samarajeewa *et al*., 1997). Nitrogen retained

was expectedly good in the reference diet than the others, however rats fed oven dried test materials had higher nitrogen retention than those sun dried which was better in ODFCOM. Processing by oven drying to an extent improved the utilization of coconut oil meal as clearly revealed in the values of apparent digestibility of nitrogen, true digestibility, biological value, protein efficiency ratio, net protein ratio and the net protein utilization. Oven drying at low heat and fermentation improves palatability enhance digestion, absorption and make the locked nutrients in the food available through detoxification and breaking of biochemical bonds at excited state (Agbede, 2004; Fowomola and Akindahunsi, 2005; Fasuyi, 2005). The gross protein values for the oven dried portions of the test ingredients improved over the sun dried parts. ODCOM had 10.25% GPV increment over SDCOM while ODFCOM recorded 4.95% above SDFCOM. The GPV had a linear relationship with true protein digestibility (Fig. 1) and the values are strongly correlated having $R^2 = 0.98$. This implies that a vegetable protein of poor digestibility value will have a corresponding gross protein value which agreed with the report of Nambi *et al*. (1991). The amino acid composition may have also influenced the true protein digestibility as there was increased value of the essential amino acids in the oven dried test ingredients when compared with their sun dried counterpart as clearly shown in Fig. 2. This finding is contrary to the report of Nambi *et al*. (1991) that oven drying

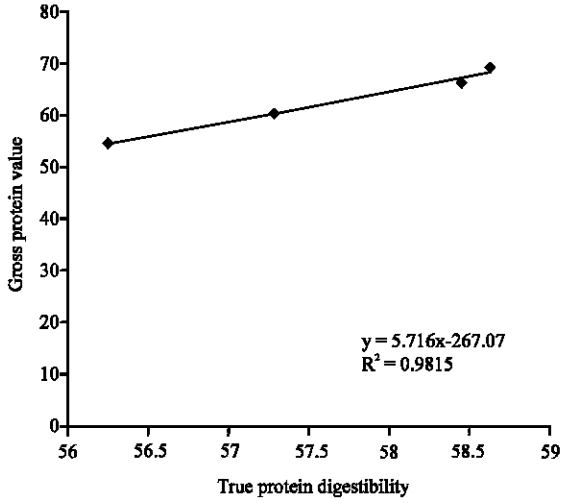

Fig. 1: Relationship between gross protein value and true protein digestibility of sun dried, fermented and oven dried processed coconut oil meals

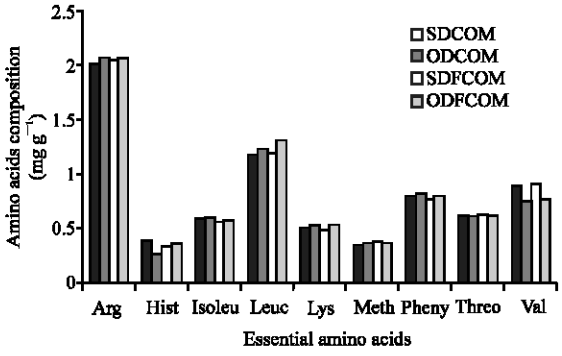

Fig. 2: Essential amino acids content of sun dried, fermented and oven dried processed coconut oil meals

reduced the essential amino acid level in poultry waste as compared with the solar-dried and sun dried. The discrepancies in the findings may have been due to autoclaving effect used to reduce the pathogens in the poultry waste. However it agrees with the report of Fasuyi (2005) and Fowomola and Akindahunsi (2005). The amino acids values obtained for the test protein dried differently in this study were similar to those reported by Thorne (1992). The lysine, methionine plus cystine and threonine values were low and fell within the range reported (Creswell and Brooks, 1971; Thorne, 1992). The drying at low temperature and fermentation process may have contributed to the observed increase in the values of some of the essential amino acids.

The mineral content of coconut oil meal is as shown in Table 4 and has been found to be very poor but fairly rich in K especially in the fermented coconut oil meal. Coconut oil meal is a poor source of the macro minerals such as Ca and P, hence must be supplemented when used in animal feed.

Conclusions

Conclusively, oven dried fermented coconut oil meal exhibited better protein quality index values than the sun dried or the fermented samples. It is therefore recommended that fermentation along with oven drying at low heat will improve the feeding value of coconut oil meal in animal diet.

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