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Supplemental Increase of Vegetable Oil in Pig Feed Formulated from Agro-Industrial Waste: Effects on Body Weight and Biochemical Parameters of Pigs

Aimuamhosa, O. S.[1], Orororo, O.C.[2*], Tonukari, N.J.[1] and Avwioroko, O.J.[3]

[1]Department of Biochemistry, Delta State University, Abraka, Nigeria.
[2]Department of Chemical Sciences, Edwin Clark University, Kiagbodo, Delta State, Nigeria.
[3]Department of Biochemistry, Redeemer's University, Nigeria

*Corresponding author Email: osuvwec@yahoo.com Tel: +234 (0) 806 230 6783

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ABSTRACT: This study was conducted to evaluate the effect of supplemental increase of vegetable oil in pig feed formulated from agro-industrial waste on body weight and biochemical parameters of pigs. Twelve female large White x Dunroc weaner pigs (15.5 ± 0.82kg) were divided into four treatment groups (A-D) corresponding to four formulated diets. Diet A (control) contained compounded diet without vegetable oil, while diets B, C, and D contained compounded diet with 1, 2, and 3% supplemental vegetable oil respectively. The animals were treated for two weeks. Significant (p<0.05) body weight gain was recorded in pigs feed with diets containing vegetable oil (Groups C and D) compared to the control (Group A). A Significant difference (p<0.05) was observed in total protein value between the control and pigs feed diet supplemented with 2% vegetable oil. There was also a significant difference (p<0.05) in albumin levels in control pigs compared to the test groups, but no significant difference was observed in albumin levels between the test groups. Serum urea and calcium levels were not significantly different across the groups, whereas cholesterol levels differed significantly across the groups. This study has demonstrated that pig feed formulated from agro-industrial waste can be supplemented with up to 3% vegetable oil without deleterious effects on the health status of pigs. The supplementation of pig diet with vegetable oil resulted in increased body weight of pigs. The 2% supplementation with vegetable oil resulted in the highest weight gain and had better effects on health status of pigs as revealed by the biochemical parameters examined.

Keywords: Grower swine, Compounded diet, Vegetable oil, Growth performance, Blood serum biochemistry.

Introduction

Pig production in Nigeria has witnessed tremendous increase in recent times given the facts that it has been recognized as a veritable tool in solving protein deficiency in the country, due to the short generation time and productiveness of pigs and their ability to efficiently convert nutrient into protein (John *et al.,* 2014; Nkwengulila, 2014; Tewe, 2008). However, one major constraint faced by pig farmers is the high cost of feeds, which has been estimated to gulp as much as 60 – 80% of total cost due partly to the high cost of conventional feed materials such as maize and wheat (Tewe *et al.,* 2008).

To solve this problem, scholars have tested and advocated the use of agro-industrial wastes and other non-conventional feed ingredients, which are abundant in the country, such as cassava peels, palm kernel cake (PKC) and brewer's spent grain (BSG) (Tewe *et al.*, 2008; Nnadi *et al.*, 2010; Adesehinwa *et al.,* 2011; Woyengo *et al.*, 2014; Orororo *et al.*, 2014; Tonukari *et al.,* 2016). Most non- conventional pig feeds, however, have low nutrient value and density, and thus require additives and supplements for optimum results (Amata,

2014). One essential supplement is vegetable oil, but reports on it as a supplement for pig feed in Nigeria are rare.

Vegetable oil is a source of essential fatty acids (which pigs cannot synthesize), fat-soluble vitamins and antioxidants that play important roles in cellular metabolism (Shurson *et al.*, 2007; Tartrakoon *et al.*, 2016). In addition, vegetable oil can increase the energy density of feed (Harper *et al.*, 2007; Shurson *et al.*, 2015; Picklo *et al.*, 2017; Chen *et al.*, 2021), boost feed's overall efficiencies (Rosero-Tapia *et al.*, 2011; Mielczarek *et al.*, 2012) and improve feed's digestibility and palatability (Vansickle *et al.*, 2010; Upadhaya *et al.*, 2017). Vegetable oil is also of value in feed manufacturing process as it aids in lubricating equipments used in pelleting, improve quality of pellets and increase throughput (Derouchey *et al.*, 2011).

This study was therefore designed to evaluate the effect of supplemental increase of vegetable oil in pig feed formulated from agro-industrial waste on body weight and biochemical parameters of pigs.

Materials and methods

Plant materials: Brewer's Spent Grain, Palm Kernel Cake, Dried Cassava peels, ARL Pig GF Megamix, and Vegetable oil were obtained from the African Research Laboratory, Otorho-Agbon, Delta State, Nigeria.

Animals: Twelve female large White x Dunroc weaner pigs of 95–100 days old weighing 15.5 ± 0.82 kg were used for the study. They were weighed and injected with Ivomec® (Ivermectin) subcutaneously, before the start of the feeding trial, to control endo-and ecto-parasites. The animals were fed with their respective diets *ad libitum* and water was made available regularly. They were also given antibiotics (Tetracycline LA) injection to ensure good health.

Experimental Design: Twelve pigs were randomly divided into four treatment groups, with three per group. Randomized and distributed to four treatments at the rate of three pigs per treatment group. The compound feeds were bagged into four groups including the control. The control diet is devoid of vegetable oil and the test treatment diets had vegetable oil in various amounts as show in Table 1:

Table 1: Experimental design/percentage composition of the experimental diets

Diet Composition	**Group A (Control)**	**Group B**	**Group C**	**Group D**
Brewer's Spent Grain BSG (%)	24.25	24.25	24.25	24.25
Palm Kernel Cake PKC (%)	45	45	45	45
Cassava Peel (%)	20	20	20	20
Vegetable Oil (%)	0	1	2	3
ARL Pig GF Megamix* (%)	10.75	10.75	10.75	10.75

*Pig Feed (GF) Megamix = [Methionine 1 kg, lysine 3 kg, grower premix 10 g, salt 30 kg and enzyme 0.1 kg]

The pigs were fed with their respective diets for two weeks. Proximate analysis of the feeds was carried out using standard laboratory protocols as described by the Association of Analytical Chemists (AOAC), (1996). At the end of the feeding trial, the weight of the pigs was taken and their weights were taken and blood samples collected via ear vein puncture method using a sterilized needle and syringe. Biochemical assays were subsequently carried out using serum obtained from the blood samples.

Biochemical assays: The biuret method was used in the determination of total protein concentration (g/dl) as described by Tietz (1995) following the Randox assay kit protocol using. Albumin concentration (g/dl) was measured following the procedure of Doumas *et al.* (1971). Glucose and urea concentration (mg/dl) were determined following the methods described by glucose oxidase method as described by Trinder (1969) and Weatherburn (1967) in accordance with the Randox Assay kit information. Cholesterol levels were determined by the method of Trinder (1969), while serum calcium concentration (mg/dl) was determined according to the method of Lothar (1998). Metabolisable energy was estimated using the proximate analysis data as shown in the AOAC (1995) formula:

$$\text{Metabolisable energy (Kcal/kg)} = (37 \times CP) + (81.8 \times CF) + (35.5 \times NFE)$$

Statistical analysis: All the data obtained were subjected to statistical analysis of variance (ANOVA) and Least Significance Test (LSD) procedure using the SPSS software. Results are expressed as Mean ± SD.

Results

Proximate analysis of feed ingredients and compounded feeds: The Proximate Composition of Brewers' Spent Grain (BSG), Dried Cassava Peels, Palm Kernel Cake (PKC), and Compounded Feeds are shown in Table 2. Addition of vegetable oil to the compounded diet increased percentage fat content from 11.7±1.6 in the control diet to 13.5±1.1, 14.1±0.6 and 14.7±1.2 in group B, C, and D diets respectively. Percentage protein content ranged from 3.15±0.5 in cassava peels to 19.5±1.1 (compounded diet with 2% vegetable oil). Conversely, cassava peels has the highest percentage moisture content (5.76±0.2) while BSG had the least (1.3±0.2). Compounded feed containing 3% vegetable oil (Group D) had the highest metabolizable energy (4124.81), with PKC having the least (1717.8).

Table 2: Proximate composition of brewers' spent grain (BSG), dried cassava peels, palm kernel cake (PKC), and compounded feed.

Parameters	BSG	PKC	Cassava Peels	Compounded feeds			
				A	B	C	D
Crude Protein (%)	14.3±0.1	15.5±0.3	3.15±0.5	19.1±1.8	19.3±1.2	19.5±1.1	19.4±1.0
Fat Content (%)	9.6±0.3	8 ±0.2	1.24±0.26	11.7±1.6	13.5±1.1	14.1±0.6	14.7±1.2
Crude Fiber (%)	3.2±0.1	17±0.28	31.96±0.4	20.4±1.3	20.2±1.1	20.1±1.0	20.0±1.5
Ash Content (%)	4.2 ±0.2	3.3±0.1	5.42±0.36	10.9±0.4	10.9±0.8	10.7±1.0	10.9±1.2
Moisture Content (%)	1.3±0.2	2±0.17	5.76±0.2	2.4±0.24	2.6±0.21	2.7±0.22	2.8±0.23
Carbohydrate Content (%)	60.5±0.6	13.8±0.08	45.7±2.4	51.6±1.4	51.2±1.2	51.1±1.1	51.0±1.0
Dry Matter (%)	64.6±0.29	64.5±0.25	61.24±0.1	62.4±0.8	62.0±1.1	62.3±0.5	62.1±0.4
Metabolizable energy(kcal/kg)	3462.13	1717.8	1840.3	3897.96	4019.10	4086.53	4124.81

Effect of supplemental increase of vegetable oil in pig feed formulated from agro-industrial waste on body weight gain of experimental pigs: Effect of supplemental increase of vegetable oil in pig feed formulated from agro-industrial waste on the body weight gain of experimental pigs is shown in Figure 1. Live weight gain was compared among the pigs in the different experimental groups. Pigs fed only with the compounded feed group A (control) had body weight gain of 0.50±0.20kg; significant body weight gain was recorded in pigs feed with diets containing vegetable oil (Groups C and D) compared to the control (Group A). Pigs feed diet containing 2% vegetable oil had the highest body weight gain (2.0±0.49kg), followed by those feed with diet containing 3% vegetable oil (1.70±0.22kg).

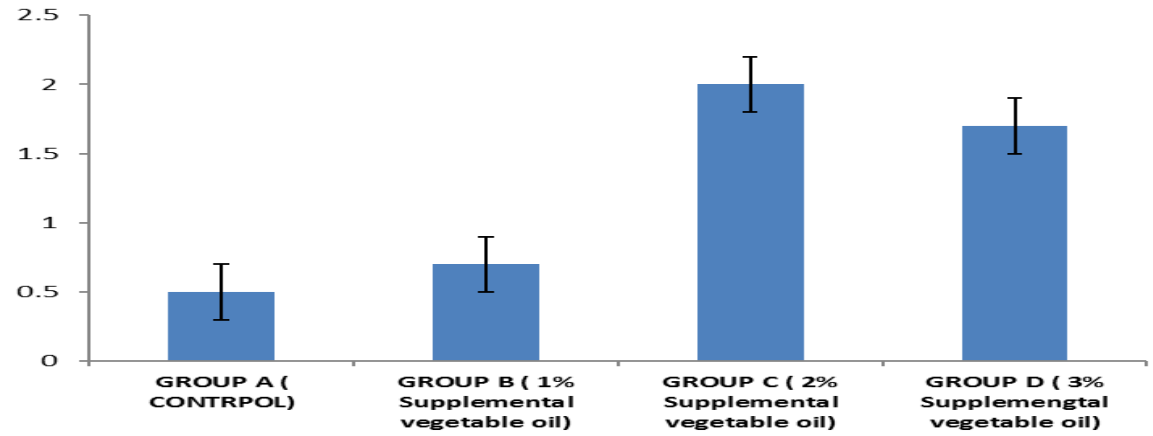

Figure 1: Body weight gain (kg) of experimental pigs

Effect of supplemental increase of vegetable oil in pig feed formulated from agro-industrial waste on serum parameters of experimental pigs: The effect of supplemental increase of vegetable oil in pig feed formulated from agro-industrial waste on serum parameters of experimental pigs is presented in Table 3. Total protein values ranged from 8.17 ± 0.1in the control to 12.75 ± 0.1 in pigs fed diet supplemented with 2% vegetable oil. A Significant difference ($p<0.05$) was observed in total protein value between the control and pigs feed diet supplemented with 2% vegetable oil. Feeding pigs diet supplemented with 1% (group B) and 3% (group D) vegetable oil did not produce any significant difference in levels of total protein compared to control.

There was a significant difference ($p<0.05$) in albumin levels in control pigs compared to the test groups, but no significant difference was observed in albumin levels between the test groups. Supplementation of compounded feed with 1%, 2% and 3% vegetable oil did not cause significant increase in glucose levels compared to the control. Serum urea and calcium levels were not significantly different across the groups, whereas cholesterol levels differed significantly across the groups. Pigs maintained on diets supplemented with 1%, 2% and 3% vegetable oil had significantly higher cholesterol levels compared to control.

Table 3: Effect of supplemental increase of vegetable oil in pig feed formulated from agro-industrial waste on serum parameters of experimental pigs

Parameters	Group A	Group B	Group C	Group D
Total Protein(g/dl)	$8.17^{a} \pm 0.6$	$10.59^{a} \pm 0.2$	$12.75^{b} \pm 0.5$	$9.54^{a} \pm 0.6$
Albumin (g/dl)	$14.04^{a} \pm 1.4$	$26.12^{b} \pm 0.5$	$28.49^{b} \pm 0.7$	$24.41^{b} \pm 0.9$
Glucose(mg/dl)	$119.21^{a} \pm 1.3$	$124.62^{a} \pm 1.2$	$1223.41^{a} \pm 1.8$	$122.34^{a} \pm 1.3$
Urea (mg/dl)	$109.32^{a} \pm 1.8$	$111.41^{a} \pm 1.4$	$110.11^{a} \pm 1.5$	$112.07^{a} \pm 1.4$
Cholesterol(mg/dl)	$68.24^{a} \pm 0.9$	$82.36^{b} \pm 1.1$	$80.40^{b} \pm 1.2$	$80.28^{b} \pm 1.2$
Calcium (mg/dl)	$20.33^{a} \pm 0.7$	$21.48^{a} \pm 0.5$	$22.34^{a} \pm 0.7$	$20.56^{a} \pm 0.9$

Values are presented as mean ± SD. Values on the same row with different superscript differ significantly ($P<0.05$); **GROUP A** (Control)**:** Experimental diet only; **Group B:** Experimental diet supplemented with 1%vegetable oil; **Group C:** Experimental diet supplemented with 2 %vegetable oil; **Group D:** Experimental diet supplemented with 3 % vegetable oil.

Discussion

The effect of supplementation of pig feed formulated from agro-industrial waste on body weight and biochemical parameters of pigs was examined in this study. The control and test diets brought about increase in body weight of pigs, but the test diets caused significant increase in weight then the control diet. The results suggest that the diets meet the nutritional needs of the animals (Souza *et al.*, 2020; Olajide *et al.*, 2019). The comparable weight gain obtained with the supplementation of the control diet with 1%, 2% and 3% vegetable oil is evidence that the test diets were able to meet the lysine and other amino acids (AA) needs of the experimental pigs. The result of the present study showed that pigs can accommodate inclusion of vegetale oil in their diets without any harmful consequences in their body weight gain (Adebiyi *et al.*, 2020). The increase in weight gain observed can also be attributed to the reduction in fibre content of the test diets feeds upon the addition of vegetable oil. According to Adesehinwa (2011), the protein content and utilization of feeds decreases as the fibre content of the feed increases. The use of vegetable oil as supplement in a diet containing cassava peel may have reduced its dustiness and increased its palatability (Orororo *et al.*, 2014). Increased feed intake may have resulted in increased body weight gain.

The effect of the diet on some biochemical parameters of the pigs as shown in Table 3 supports the position of Szponar *et al*. (2003), Anayo (2010) and Adeyemi *et al.* (2016) that nutrition affects the weight and blood parameters of animals. The basic functioning units of cells are made up of proteins as enzymes, immunoglubolins, antibodies are proteins and as such play important roles in cells(Adesehinwa, 2010). The protein levels recorded in the pigs feed the compounded diets are within normal ranges and point to the fact that the protein levels in the diets adequately supported normal protein reserves in the pigs.

Low levels of albumin have been attributed to protein shortage (Gouache *et al.*, 1991), but that was not witnessed in this study as the albumin levels in pigs feed the control and test diets were within normal range. The high level of Albumin observed in the test groups may be due to vegetable oil supplemented on the control diet that improved the serum total protein with the corresponding increase in the serum albumin. One of the cellular functions of albumin, depending on the cellular state, is the transport of fatty for oxidation or storage in adipose tissues (Shinawi and Abu-Elheiga, 2014). The higher body weight gain of pigs maintained on the test diets compared to the control may also be connected to their higher serum albumin levels, which may have facilitated the storage of fatty acids as triacylglycerols (Dunning *et al.*, 2014). In addition, because of its capacity to prevent bleeding, albumin is essential for blood, thus, higher values of albumin is beneficial to the pigs (Anyo, 2010; Gouache *et al.*, 1991).

Serum urea values recorded was not statistically different between the groups. Urea is a product of muscle metabolism and its level in the blood is significant in measuring muscular wastage and kidney function, with significant high levels indicating kidney damage, and poor utilization of dietary protein (Alu *et al.*, 2011; Atta *et*

al., 2010). This was not witnessed in this study as the urea levels recorded were within normal values which indicate that the diets were adequate for the pigs and did not instigate any toxic effect on their kidneys.
Cassava peel is a highly fibrous ingredient of feed, which may affect its utilization. The supplemental increase of vegetable oil in the diet may have enhanced the effective utilization and digestibility of the fibrous contents of the control diets (Sawyer *et al.,* 2013). No significant difference was observed in glucose concentration across the groups which indicate that the carbohydrate components of the diet were able to provide a reasonable energy for growth and normal function of the pig. Glucose is the major source of energy to the pig and must be supplied adequately to maintain its blood concentration of proper utilization by the targeted tissues or cells. The observed increase in serum cholesterol in pigs maintained on the test diets compared to the control may be due to increased cholesterol in the test diets due to supplementation with vegetable oil, which contains cholesterol and other fatty acids (Tartrakoon *et al.,* 2016). Raval *et al.* (2021) also reported increased cholesterol levels in serum of pigs feed diet containing vegetable oil. Calcium is needed for healthy skeletal functions, nerves function and maintenance of membrane integrity. The diets in this study supplied the necessary calcium for normal pig body function. This is in agreement with the report of DeRouchey *et al.* (2010) that calcium from plant is readily bio-available to pigs being relatively digestible by non-ruminants.

Conclusion

This study has demonstrated that pig feed formulated from agro-industrial waste can be supplemented with up to 3% vegetable oil without deleterious effects on the health status of pigs. The supplementation of pig diet with vegetable oil resulted in increased body weight of pigs which will be beneficial to pig farmers. The 2% supplementation with vegetable oil resulted in the highest weight gain and had better effects on health status of pigs as revealed by the biochemical parameters examined.

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