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Effect of processing methods on the utilization of shrimp waste by broiler chickens

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Abstract

Two hundred and forty unsexed broiler birds of Anak breeds at one week of age were used to study the utilization of potash treated shrimp waste meal (SWM) in broiler diets fed as mash or pellet form in a 2x2x2 factorial experiment. The birds used were randomly allotted to eight treatment groups with three replications. SWM used was either potash treated or untreated, plate milled or hammer milled. Growth performance, nutrient utilization, and carcass characteristic were measured. Potash treatment of SWM led to a significant increase ($P<0.05$) in final live weight of the birds at starter phase, but such effect was not noticed at finisher phase. Starter broilers fed mash diets had a significantly ($P<0.05$) higher mean final live weight (519.08g), than those fed pelleted diet (493.42), but the difference at finisher phase was not significant. The processing methods did not significantly ($P>0.05$) improve the performance of the birds at finisher phase, though slight improvement was noticed in birds fed pelleted diets. The processing methods did not significantly ($P>0.05$) influence the protein retention, ash and ether extract digestibility at starter phase. Crude fibre digestibility was significantly ($P<0.05$) improved by plate milling and pelleting of the diets, and the interactions of the processing methods. Dry matter digestibility and crude protein retention of finisher broilers were significantly ($P<0.05$) improved by the dietary treatments. It was concluded that the treatments employed yielded no commendable performance in broilers. Pelleting of SWM based diets slightly improved its utilization by finishing broiler chickens.

Keywords: **Processing methods, Utilization, shrimp waste, broiler chicken**

Introduction

The poultry industry in Nigeria is currently faced with high cost of inputs most especially the feed. Research efforts had been geared toward the use of locally available alternative feedstuff such as agro-industrial by-products and farm waste that may bring about the expected reduction in feed cost and consequently poultry products. The various investigations on the use of cheaper industrial by-products and farm wastes in poultry nutrition have been intensified with the aim of determining their efficiency of utilization for growth and production.

Shrimp waste meal (SWM) is basically the dried milled waste of the shrimp industry, consisting the head, appendages and exoskeleton of the shrimp (Fanimo *et al* 1996, Rosenfeld *et al* 1997).

This product have bee identified as having a high potential of being an alternative protein source in broiler ration (Rosenfeld *et al* 1997). It is particularly rich in lysine which makes it an ideal supplement to cereals. The level of use of shrimp waste meal in poultry ration has been low. This might be due to high chitin, which constitutes about 14-27% of the total shrimp waste (Ferrer *et al*, 1996).

Several nutritional manipulations have been effected on shrimp waste with the aim of improving its use. Oduguwa *et al* (1998) used different drying methods; Fanimo *et al* (1996) supplemented shrimp waste based diets with synthetic amino acid while Oduguwa *et al* (2002) supplemented shrimp waste diets with exogenous enzyme. The results of these treatments did not measure up to the result obtained when fishmeal was used. This study further investigated other processing methods and their effects on growth and nutrient utilization of broiler chicken.

Materials and Methods

The experiment was carried out at the Poultry unit of the Teaching and Research farm of the University of Agriculture, Abeokuta. The SWM used in this study was obtained from CHI Ltd Lagos. The SWM collected in its wet form was either treated with potash or left untreated. The treatment involved boiling the wet SWM in bags with 0.5% potash solution ($NaHCO_3.H_2O$) for 30 minutes. Both the treated and untreated SWM were sun-dried prior to milling. The treated and untreated SWM was made to undergo two milling processes viz hammer milled (to pass through 2mm screen) and plate milled (finely ground). The resulting SWM samples were then incorporated into the diets, which was presented either as mash or as 5mm pellets (produced with the use of live steam in a commercial mill).

Two hundred and forty unsexed broiler chicks of Anak breeds and one week of age were randomly allotted into eight (8) treatment groups of 30 birds each. Each treatment group was replicated thrice with 10 birds per replicate. The group was randomly assigned to eight (8) isocaloric and iso-nitrogenous diets in a 2x2x2 factorial design. The experimental diets comprises untreated hammer milled SWM in mash form (UHSM), untreated hammer milled SWM in pellet form (UHSP), untreated plate milled SWM in mash form (UPSM), untreated plate milled SWM in pellet form (UPSP), potash treated hammer milled SWM in mash form (PHSM), potash treated hammer milled SWM in pellet form (PHSP), potash treated plate milled SWM in mash form (PPSM), and potash treated plate milled SWM in pellet form (PPSP). The birds were fed starter diets from 1-5 (Table 1) weeks while finisher diets were given to the birds from 6-9 weeks (Table 2). Feed and water was supplied *ad-libitum*.

Birds and feed consumption were weighed weekly. The cost per kilogram feed and cost of feed per kilogram weight gain was determined. At the 4th and 8th week of the experiment, two birds per replicate were randomly selected and transferred into the metabolic cages. Weighed quantity of feed was supplied and excreta collected over a period of three days. A three days acclimatization period was allowed prior to the collection of droppings. Excreta samples were oven dried at 65 °C for 72 hours, ground and analyzed for crude protein (CP), crude fibre (CF), ether extract (EE) ash, nitrogen free extract (NFE) and dry matter (DM) (AOAC, 1990). Crude protein retention and metabolisability of DM, CP, CF EE, NFE and ash were determined. At the end of eight weeks of the experiment, two birds per replicate were selected, weighed, slaughtered and dressed. Dressed carcass and relative fresh organ (liver, lung, heart, kidney etc) weights (expressed as a percentage of live weights) were recorded. Data obtained were subjected to analysis of variance. Significant means were separated using Duncan's Multiple Range Test (Duncan, 1955).

Table 1: *Composition of experimental diets at the starter phase.*

Diets	1	2	3	4	5	6	7	8
Ingredients	UHSM	UHSP	UPSM	UPSP	PHSM	PHSP	PPSM	PPSP
Maize	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50
SBM (Toasted)	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50
GNC	12.50	12.50	12.50	12.50	15.00	15.00	15.00	15.00
SWM	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
BDG	7.68	7.68	7.68	7.68	5.18	5.18	5.18	5.18
Bone meal	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Oyster shell	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Premix	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Lysine	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Determined Analysis								
Crude protein(%)	23.62	24.06	23.84	23.41	23.84	23.78	24.10	24.30
Ether Extract(%)	6.33	5.87	5.30	6.33	5.82	5.30	6.33	5.82
Ash(%)	13.00	17.00	10.50	14.00	11.30	16.71	13.40	14.31
Crude fibre(%)	4.75	4.86	4.32	4.61	4.34	4.35	4.20	4.38

UHSM = Untreated hammer milled SWM diet (meal)
UHSP = Untreated hammer milled SWM diet (pellet)
UPSM = Untreated plate milled SWM diet (meal)
UPSP = Untreated plate milled SWM diet (pellet)
PHSM = Potash treated hammer milled SWM diet (meal)
PHSP = Potash treated hammer milled SWM diet (pellet)
PPSM = Potash treated plate milled SWM diet (meal)
PPSP = Potash treated plate milled SWM diet (pellet)

Results and Discussion

The chemical composition of potash treated and untreated SWM is presented in Table 3. The crude protein content of the untreated SWM was higher (40.08%) than the potash treated (32.20%). The percentages dry matter, crude fibre, ether extract, ash, and nitrogen free extract values were higher in potash treated SWM.

At starter phase, birds on potash treated SWM recorded a significantly ($P<0.05$) higher final live weight (Table 4). The daily feed intake, daily protein intake and daily weight gain were not significantly influenced by the potash treatment ($P>0.05$). Potash being a tenderizer may have exhibited its attribute on chitin, which is the major antinutritional factor in SWM thus making nutrients more available for the birds for growth. Besides, local potash was reported to contain calcium (3.47%), phosphorus (32.5%), sodium (20.19%), potassium (6.08%), magnesium (0.63%), Iron (0.89%), copper (0.73%), zinc (0.67%), chlorine (16.25mg/l), HCO_3 (13.55mg/l) and carbonate (12.80mg/l) (Adeleye, *et al.*, 2004) which are capable of enhancing better performance of the birds.

Table 2: *Composition of experimental diets at the finisher phase*

Diets Treatment	1 UHSM	2 UHSP	3 UPSM	4 UPSP	5 PHSM	6 PHSP	7 PPSM	8 PPSP
Maize	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
SBM (Toasted)	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
GNC	11.00	11.00	11.00	11.00	12.00	12.00	12.00	12.00
SWM	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
BDG	9.33	9.33	9.33	9.33	8.33	8.33	8.33	8.33
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Oyster shell	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Premix	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Lysine	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Determined Analysis								
Crude protein (%)	21.31	21.31	22.56	22.75	22.09	22.41	21.66	22.13
Crude fibre (%)	5.40	4.88	5.41	4.90	4.82	4.85	5.02	4.78
Ether extract	7.78	5.46	8.78	7.78	6.68	6.14	7.78	5.01
Ash (%)	12.00	13.50	11.50	13.80	13.61	14.20	12.01	13.97

Table 3: *Proximate composition of untreated and potash treated shrimp waste*

Composition	Untreated SWM	Potash treated SWM.
Dry Matter (%)	88.25	92.42
Crude protein (%)	40.08	32.20
Crude fibre (%)	9.62	11.53
NFE (%)	24.56	27.45
Ash (%)	19.22	20.22
Ether extract	6.25	8.60

Birds fed mash diets had higher (P<0.05) final live weight value compared to those fed pellet diets. This observation is contrary to finding of Munt, *et al*, (1995) who reported a higher significantly higher final live weight for starter broiler fed pellet diet. The inability of pellet diet to make a significant impact at this phase may be attributed to the fact that the gastro-intestinal tract of the starter broilers may not have matured enough to properly cope with the digestion and utilization of pellet diets. The slightly lowered feed conversion ratio and slightly increased weight gain value recorded for bird fed hammer milled diets is in agreement with Pond, *et al* (1995). He reported that medium to moderately fine textured feeds results in better performance than when they are finely ground. Dirkzwager *et al*, (1998) also reported an increased feed conversion by coarse milling. At finisher phase, the final live weight of the birds was slightly improved by untreated SWM. The lower final live weight value recorded for the birds fed potash treated SWM diets might be due to the treatment employed which involved boiling shrimp waste in potash solution. The treatment may have led to the loss of some nutrients particularly some amino acids thereby lowering the quality of SWM protein hence, resulting in lower live weight. Samuel *et al*, (1999) observed a significant ($P<0.05$) decrease in the level of some amino acid such as lysine, isoleucine, tyrosine, phenylalanine, and threonine after cooking black beans with kanwa (local potash). The non-significant effect of pelleting on performance of finisher broilers agreed with the findings of Hull et al, (1968). The observation could be related to the condition that the integrity of pellet in terms of stability and cohesion must be high in order for the birds to utilize pellet to a productive advantage. The cost of feed per weight gain at finisher phase shows that it is most economical producing broilers on untreated hammer milled SWM fed as pellet. The cost of producing one kg of broiler meat was reduced when pellet was fed to broilers than mash. The mean values of the nutrient digestibility of starter broilers as influenced by the dietary treatments are shown in Table 9. Birds fed pellet diets had a significantly ($P<0.05$) higher feed intake value than those fed mash. The mouth of the bird is particularly suited to benefit from pellets. The ease of prehension, less energy and time required for prehension as well as reduced feed wastage (Deaton *et al*, 1987) might be responsible for the higher intake of pellet diets. Crude protein intake was significantly ($P<0.05$) influenced by potash treatment and form of feed. The higher intake of potash treated and pellet diets might be responsible for the observation. Crude fibre digestibility was significantly ($P<0.05$) improved by plate milling and pelleting (Table 10). Plate milling ensures fine grinding and pelleting, which ensure rupturing of cell wall of diets might be responsible for this observation.

The dry matter, ether extract, ash and crude fibre digestibility values obtained for metabolic trial at finisher phase (Table 11) resulted in marked difference when compared with those of starter phase (Table 10). It was cleared that as the bird's matured, nutrient digestibility increased with finisher broilers having higher digestibility values than starter (Oduguwa *et al* 2002). Feed intake was significantly ($P<0.05$) affected by potash treatment. This observation deviated from the trend observed at the starter phase. Birds fed plate milled SWM diets recorded a higher dry matter digestibility. SWM in its fine (plate milled) form, is expected to have a higher surface area, making it more susceptible to enzymatic breakdown. Pelleting of SWM based diets significantly improve its digestibility. This might be due to rupturing of the cell wall of the ingredient, occasioned by the combination of heat and intense mechanical share force during pelleting (Van de *et al*, 1988). The protein retention was significantly ($P<0.05$) influenced by the various treatment employed. There was a remarkable improvement in crude protein retention at the finisher phase. The crude protein retention increased as the birds matured (Oduguwa *et al* 2002).

Results of the carcass analysis (Table 14) showed that the dressed weight (expressed as percentage live weight) was significantly ($P<0.05$) influenced by the interactions of grinding methods and form of feed and of the three processing methods employed. Dressed weight could be said to be of much importance to poultry meat consumer than the live weight because feathers forms an addition to this. In this study, the dressing percentage varied from 72.91 – 74.12%. Thigh weight was significantly ($P<0.05$) affected by forms of feed. Higher weight of thigh meat, one of the expensive and highly valued commercial cut of the chicken, in birds fed pelleted diets over those fed mash is an index of superiority of pelleted diets in broiler feeding on account of the degree of carcass meatiness and revenue yield. Similar

Table 4: *Main effect of potash treatment, grinding methods and forms of feed of shrimp waste on the performance of Broilers starter fed experimental diets.*

Treatments	Potash treatment			Grinding methods			Forms of feed		
	USWM	PSWM	SEM	HSWM	PMSW	SEM	SWMM	SWMP	SEM
Initial live weight (g/bird)	109.75	110.00	0.125	108.08	111.67	1.79	112.25	107.50	2.37
Final live weight (g/bird)	497.08^{b}	515.42^{a}	9.17	501.00	511.50	5.25	519.08^{a}	493.42^{b}	12.83
Daily feed intake (g/bird)	68.85	70.15	0.36	69.20	69.80	0.03	69.99	69.02	0.11
Daily weight gain (g/bird)	19.27	19.98	0.65	19.65	19.60	0.30	19.51	19.73	0.48
Daily protein intake (g/bird)	16.34	16.84	0.25	16.45	16.70	0.13	16.69	16.49	0.10
Feed conversion ratio	3.65	3.55	0.05	3.57	3.63	0.03	3.68	3.52	0.08
Protein efficiency ratio	1.18	1.19	0.01	1.19	1.18	0.01	1.17	1.20	0.02
Cost of feed/kg diet ··	37.71	38.92	0.11	38.71	38.83	0.16	38.92	40.32	0.70
Cost of feed/kg weight gain	141.29	138.17	1.56	138.19	140.95	1.38	143.23	141.93	0.65

^{a,b} Means on the same row having the same superscripts are not significantly different ($P>0.05$)

USWM = Untreated shrimp waste meal
PSWM = Potash treated shrimp waste meal
HSWM = Hammer milled shrimp waste meal
PMSW = Plate milled shrimp waste meal
SWMM = Shrimp waste meal (meal)
SWMP = Shrimp waste meal (pellet)

Table 5: *Interactive effect of the dietary treatments on the performance of birds fed experimental diets (Starter phase)*

Treatments	Potash treatment x grinding method					Potash treatment x form of feed					Grinding method x form of feed				
	UHMS	UPMS	PHMS	PPMS	SEM	USWM	USWP	PSWM	PSWP	SEM	HMSW	HPSW	PMSW	PPSW	SEM
Initial live weight (g/bird)	113.67	105.83	102.50	117.50	3.46	112.83	106.67	111.67	108.33	1.43	111.17	105.10	113.33	110.00	1.47
Final live weight (g/bird)	480.00^{c}	514.25^{b}	522.00^{a}	508.83^{ab}	9.16	510.83	483.33	527.33	503.50	9.12	520.33	481.67	517.83	505.17	8.84
Weight gain (g/bird/day)	19.01	19.53	20.29	19.67	0.43	18.95	19.58	20.06	19.89	0.56	19.75	19.54	19.26	19.93	0.35
Total feed intake (g/bird)	68.38	69.32	70.01	70.29	0.26	69.87	67.83	70.10	70.20	0.24	69.87	68.52	70.10	69.51	0.14
Protein intake (g/bird)	16.20	16.43	16.59	16.66	0.04	16.48	16.08	16.61	16.63	0.08	16.48	16.21	16.61	16.32	0.05
Feed conversion ratio	3.66	3.65	3.48	3.63	0.10	3.83	3.48	3.53	3.57	0.13	3.63	3.51	3.73	3.54	0.09
PER	1.17	1.19	1.22	1.18	0.01	1.15	1.22	1.21	1.20	0.02	1.20	1.21	1.16	1.22	0.013

Means on the same row having the same superscript are not significantly different (P>0.05)

UHMS=Untreated Hammer milled SWM
HMSW=Hammer milled SWM (Meal)
USWP=Untreated SWM (Pellet)
PHMS= Potash treated Hammer milled SWM
PMSW=Plate milled SWM (Meal)

PSWP=Potash treated SWM (Pellet)

USWM=Untreated SWM (Meal)
UPMS=Untreated Plate milled SWM
HPSW= Hammer milled SWM (Pellet)
PSWM=Potash treated SWM (Meal)
PPMS= Potash treated Plate milled SWM

PPSW=Plate milled SWM (Pellet)

Table 6: *Performance characteristics of broilers fed processed shrimp waste meal diets (Starter phase)*

Treatments	UHSM	UHSP	UPSM	UPSP	PHSM	PHSP	PPSM	PPSP	SEM
Initial live weight (g/bird)	115.67	111.67	110.00	101.67	106.67	98.33	116.67	118.33	2.25
Final live weight (g/bird)	501.67	458.33	520.00	508.33	539.00	505.00	515.67	502.00	8.12
Daily weight gain (g/bird)	18.38	19.63	19.52	19.53	21.13	19.44	19.00	20.33	0.46
Daily feed intake (g/bird)	68.98	67.78	70.75	67.87	70.75	69.27	69.46	71.13	0.29
Daily protein intake (g/bird)	16.29	16.31	16.89	15.89	16.87	16.47	16.74	17.28	0.06
Feed conversion ratio	3.92	3.41	3.74	3.55	3.34	3.63	3.73	3.53	0.15
Protein efficiency ratio.	1.13	1.20	1.15	1.23	1.25	1.18	1.14	1.17	0.02
Cost of feed/kg diet (₦)	38.71	40.30	38.83	40.32	38.92	40.32	38.94	40.82	0.31
Cost of feed/kg weight gain (₦)	151.74	137.42	145.22	143.14	129.99	146.36	145.25	144.10	2.31

UHSM = Untreated hammer milled SWM (Meal)
UHSP = Untreated hammer milled SWM (Pellet)
UPSM = Untreated plate milled SWM (Meal)
UPSP = Untreated plate milled SWM (Pell et)

PHSM = Potash treated hammer milled SWM (Meal)
PHSP = Potash treated hammer milled SWM (Pellet)
PPSM = Potash treated plate milled SWM (Meal)
PPSP = Potash treated plate milled SWM (Pellet)

Table 7: *Main effect of potash treatment, grinding methods and forms of feed on the performance of broiler fed experimental diets (finisher phase)*

Treatments	Potash treatment		SEM	Grinding methods		SEM	Form of feed		SEM
	USWM	PSWM		HSWM	PMSW		SWMM	SWMP	
Initial live weight (g/bird)	497.08	515.42	9.17	501.00	511.50	5.25	519.08	493.42	12.83
Final live weight (g/bird)	1718.30	1682.50	17.90	1701.70	1699.20	1.32	1635.80	1765.00	64.46
Daily feed intake (g/bird)	158.85	166.60	0.98	160.94	164.51	0.99	160.28	165.16	2.77
Daily weight gain (g/bird)	43.68	45.65	3.88	45.66	43.69	1.78	41.89	47.43	2.44
Daily protein intake (g/bird)	34.90	36.77	0.93	35.07	36.60	0.76	35.08	36.59	0.75
Feed conversion ratio	4.17	4.14	0.01	4.02	4.29	0.13	4.42	3.89	0.26
Protein efficiency ratio	1.25	1.24	0.01	1.30	1.19	0.06	1.19	1.30	0.06
Cost of feed/kg diet (₦)	34.17	34.80	0.31	34.18	34.46	0.14	34.80	37.36	1.28
Cost of feed/kg weight gain (₦)	142.49	144.07	0.79	137.40	147.83	5.21	153.82	145.33	4.24

Table 8: *Performance characteristics of broilers fed processed shrimp waste meal diets (finisher phase)*

Treatments	UHSM	UHSP	UPSM	UPSP	PHSM	PHSP	PPSM	PPSP	SEM
Initial live weight (g/bird)	501.67	458.33	520.00	508.33	539.00	505.00	515.67	502.00	8.12
Final live weight (g/bird)	1710.00	1813.30	1633.30	1716.70	1536.70	1746.70	1663.30	1783.30	31.28
Daily weight gain (g/bird)	43.16	48.89	39.76	42.91	43.34	47.23	41.31	50.69	1.36
Daily feed intake (g/bird)	154.87	160.09	158.16	162.27	162.56	166.22	165.54	172.06	1.86
Daily protein intake (g/bird)	33.00	34.12	35.56	36.92	35.91	37.25	35.86	38.07	0.10
Feed conversion ratio	4.43	3.74	4.40	4.12	3.99	3.92	4.88	3.77	0.59
Protein efficiency ratio	1.31	1.43	1.12	1.16	1.21	1.27	1.15	1.33	0.04
Cost of feed/kg diet (₦)	31.17	36.76	34.46	36.95	34.80	37.06	36.00	37.36	0.51
Cost of feed/kg weight gain (₦)	151.37	137.48	151.62	152.23	138.85	145.27	146.88	140.85	2.11

Table 9: *Main effect of potash treatment, grinding methods and forms of feed on the nutrient digestibility of broilers fed*
experimental diets (starter phase)

Treatments	Potash Treatment			Grinding methods			Forms of feed		
	USWM	PSWM	SEM	HSWM	PMSW	SEM	SWMM	SWMP	SEM
Feed intake (g/bird)	236.00	239.00	1.50	235.82	239.61	1.89	230.42[b]	245.00[a]	7.29
Faecal output (g/bird)	65.10	64.56	0.27	63.46[b]	66.21[a]	1.38	63.29[b]	66.38[a]	1.55
Crude Protein intake (g/bird)	56.01[b]	57.80[a]	.090	56.50	57.31	0.41	54.98[b]	58.83[a]	1.92
Dry matter digestibility (%)	72.65	73.05	0.20	73.07	72.62	0.23	72.54	73.16	0.31
Crude protein retention (%)	78.53	79.57	0.52	79.12	78.97	0.07	78.19	79.91	0.86
Ether extract digestibility (%)	88.56	87.60	0.48	88.60	87.55	0.52	87.88	88.27	0.20
Ash digestibility (%)	86.31	87.15	0.42	86.68	87.55	0.04	87.88	88.27	0.69
Crude fiber digestibility (%)	83.39	84.49	0.55	83.27[b]	84.61[a]	0.70	80.34[b]	87.54[a]	3.60

[a,b] Means on the same row having the same superscripts are not significantly different (P>0.05)

Table 10: *Nutrient digestibility of broilers fed processed SWM diets (Starter phase)*

Treatments	UHSM	UHSP	UPSM	UPSP	PHSM	PHSP	PPSM	PPSP	SEM
Feed intake (g/bird)	228.30	243.93	227.21	244.57	228.70	242.35	237.50	249.16	3.04
Faecal output (g/bird)	63.87	64.87	63.78	67.91	60.85	64.25	64.65	68.51	0.86
Crude Protein intake (g/bird)	53.93	58.69	54.17	57.25	54.56	58.84	57.28	60.55	0.87
Dry matter digestibility (%)	72.02	73.38	71.93	73.25	73.39	73.49	72.80	72.51	0.22
Crude protein retention (%)	77.31	79.72	77.57	79.54	78.84	80.63	79.04	79.77	0.40
Ether extract digestibility (%)	89.90	88.51	87.36	88.45	86.88	89.13	87.39	86.99	0.39
Ash digestibility (%)	85.03	87.23	86.23	86.77	86.94	87.53	85.97	88.17	0.35
Crude fiber digestibility (%)	77.50^{c}	86.97^{a}	81.69^{b}	87.42^{a}	81.97^{b}	86.64^{a}	80.21^{bc}	89.13^{a}	1.46

^{a,b} Means on the same row having the same superscripts are not significantly different (P>0.05)

Table 11: *Main effect of potash treatment, grinding methods and forms of feed on the nutrient digestibility of broilers fed experimental diets (finisher phase)*

Treatments	Potash treatment			Grinding methods			Form of feed		
	USWM	PSWM	SEM	HSWM	PMSW	SEM	SWMM	SWMP	SEM
Feed intake (g/bird)	478.11^{b}	496.25^{a}	9.03	484.81	489.46	2.32	465.03^{b}	509.24^{a}	22.10
Faecal output (g/bird)	122.51	122.39	0.04	126.48^{a}	118.42^{b}	4.03	132.95^{a}	111.96^{b}	10.49
Crude Protein intake (g/bird)	105.38^{b}	110.72^{a}	2.67	105.65^{b}	110.46^{a}	2.40	103.31^{b}	112.80^{a}	4.75
Dry matter digestibility (%)	74.26^{b}	75.19^{a}	0.45	73.80^{b}	75.61^{a}	0.90	71.41^{b}	78.00^{a}	3.29
Crude protein retention (%)	78.05^{b}	79.47^{a}	0.71	77.63^{b}	79.89^{a}	1.13	75.80^{b}	81.72^{a}	2.98
Ether extract digestibility (%)	90.85	90.08	0.38	89.78	91.15	0.68	90.21	90.72	0.25
Ash digestibility (%)	92.68	92.15	0.27	91.97	92.87	0.45	91.39^{b}	93.45^{a}	1.03
Crude fiber digestibility (%)	91.54	88.78	1.38	91.21	89.11	1.05	88.05	92.28	2.11

^{a,b} Means on the same row having the same superscripts are not significantly different (P>0.05)

Table 12: Nutrient digestibility of broilers fed processed SWM diets (Finisher phase).

Treatments	UHSM	UHSP	UPSM	UPSP	PHSM	PHSP	PPSM	PPSP	SEM
Feed intake (g/bird)	453.21	494.68	468.60	495.92	474.42	516.92	463.90	529.43	9.46
Faecal output (g/bird)	135.22	111.46	135.56	107.81	134.90	124.35	126.10	104.20	4.58
Crude Protein intake (g/bird)	96.58	105.42	106.72	112.82	104.80	115.79	105.12	117.17	2.41
Dry matter digestibility (%)	70.17	77.53	71.07	78.27	71.56	75.94	72.82	80.27	1.34
Crude protein retention (%)	73.43^{d}	80.30^{b}	77.02^{c}	81.47^{b}	75.96^{c}	80.86^{b}	76.80^{c}	84.27^{a}	1.25
Ether extract digestibility (%)	90.24	89.95	91.60	91.63	88.20	90.74	9080	90.58	0.38
Ash digestibility (%)	91.43	92.91	92.25	94.14	91.50	92.02	90.37	94.73	0.51
Crude fiber digestibility (%)	84.17	89.96	85.91	89.84	85.75	89.09	80.94	90.75	1.22

^{a,b,c} Means on the same row having the same superscripts are not significantly different (P>0.0)

Table 13: *Main effect of potash treatment, grinding methods and forms of feed on the carcass characteristics of broilers fed experimental diets*

Treatments	Potash treatment			Grinding methods			Forms of feed		
	USWM	PSWM	SEM	HSWM	PMSW	SEM	SWMM	SWMP	SEM
Live weight (before slaughter g)	1735.80	1648.30	43.74	1717.50	1666.70	25.40	1723.30	1660.80	31.25
Dressed (%)	74.12	72.91	0.60	73.80	73.23	0.28	73.24	73.79	0.28
Thigh (%)	9.86	10.91	0.52	10.44	10.33	0.06	9.65^{b}	11.12^{a}	0.73
Wing (%)	8.58	8.72	0.07	8.45	8.85	0.20	8.59	8.71	0.06
Breast (%)	17.50	17.44	0.03	18.03	16.91	0.56	17.64	17.31	0.16
Back (%)	14.12	14.97	0.43	14.04	14.05	0.01	14.23	13.85	0.19
Neck (%)	5.18	5.32	0.03	5.32	5.19	0.07	5.27	2.24	0.02
Shank (%)	4.25	4.00	0.13	4.02	4.23	0.11	4.10	4.14	0.02
Head (%)	2.74	2.70	0.02	2.72	2.71	0.01	2.73	2.71	0.01
Drumstick (%)	10.29	9.84	0.22	10.08	10.06	0.01	10.06	10.08	0.01
Heart (%)	0.54	0.50	0.02	0.50	0.54	0.02	0.51	0.53	0.01
Liver (%)	2.22	2.16	0.03	2.16	2.22	0.03	2.25	2.13	0.06
Abdominal fat (%)	0.93	0.67	0.13	0.79	0.80	0.13	0.73	0.86	0.07
Gizzard (%) (Full wt.)	3.14	3.32	0.09	3.19	3.27	0.04	3.22	3.24	0.01
Gizzard (%) (Empty wt)	2.04	2.25	0.10	2.03	2.25	0.10	2.13	2.15	0.01
Small intestine (%) (Full wt.)	7.44^{a}	6.23^{b}	0.64	6.61	6.99	0.19	6.77	6.83	0.03
Small intestine (%) (Empty wt)	3.81^{a}	3.29^{b}	0.31	3.44	3.56	0.06	3.50	3.50	0.00
Length of intestine mkg^{-1}	0.99	0.85	0.07	0.98	0.85	0.07	0.98	0.86	0.06

^{a,b} Means on the same row having the same superscripts are not significantly different (P<0.05)

Table 14: *Carcass characteristics of the broilers fed processed SWM diets*

Treatments	UHSM	UHSP	UPSM	UPSP	PHSM	PHSP	PPSM	PPSP	
Live weight (before slaughter g)	1810.00	1666.70	1783.30	1683.30	1666.70	1726.70	1633.30	1566.70	28.02
Dressed (%)	75.45^{a}	74.67^{ab}	73.27^{ab}	73.10^{ab}	73.60^{ab}	71.46^{bc}	70.65^{c}	75.91^{a}	0.65
Thigh (%)	8.18	10.77	9.66	10.83	11.10	11.72	9.66	11.17	0.40
Wing (%)	8.19	8.43	8.51	9.19	9.78	8.41	8.89	8.81	0.11
Breast (%)	18.17	16.88	17.69	17.26	18.23	18.84	16.45	16.24	0.33
Back (%)	14.33	13.92	13.84	14.38	14.94	12.97	14.45	14.16	0.20
Neck (%)	5.63	5.22	4.96	4.92	5.34	5.09	5.15	5.75	0.10
Shank (%)	3.93	4.43	4.36	4.26	3.99	3.70	4.14	4.18	0.08
Head (%)	2.89	2.74	2.64	2.70	2.65	2.62	2.71	2.80	0.03
Drumstick (%)	10.04	10.85	10.39	9.90	10.01	9.41	9.80	10.15	0.15
Heart (%)	0.49	0.53	0.56	0.60	0.51	0.47	0.49	0.52	0.02
Liver (%)	2.24	2.30	2.27	2.07	2.21	1.88	2.27	2.28	0.12
Abdominal fat (%)	0.90	0.93	0.62	1.26	0.84	0.50	0.57	0.75	0.09
Gizzard (%) (Full wt.)	2.96	3.35	3.17	3.07	3.38	3.05	3.39	3.47	0.07
Gizzard (%) (Empty wt)	1.87	2.10	2.08	2.11	2.23	1.92	2.36	2.47	0.02
Small intestine (%) (Full wt.)	7.57	7.48	7.75	6.49	5.41	5.97	6.34	6.93	0.29
Small intestine (%) (Empty wt)	3.74	3.64	4.08	3.80	3.35	3.02	3.84	3.52	0.15
Length of intestine mkg^{-1}	0.92^{ab}	1.19^{a}	1.11^{ab}	0.77^{ab}	1.04^{ab}	0.80^{ab}	0.83^{ab}	0.71^{b}	0.06

observation was reported (Agunbiade, 2000). The wing, breast, back, neck, shank, head and drumstick weights were not significantly affected by the processing methods (Table 13). This same trend was observed for the abdominal fat and gizzard. The full and empty weights of small intestine were both influenced by potash treatment,

From the above study, the effect of potash treatment, plate milling and pelleting on SWM was not significant enough to advocate its recommendation for adoption in diets of broiler chickens.

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